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LANDSLIDE SUSCEPTIBILITY IN THE WILLIAMSPORT 1- BY 2-DEGREE QUADRANGLE, PENNSYLVANIA

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by Helen L. Delano and J. Peter Wilshusen
Bureau of Topographic and Geologic Survey

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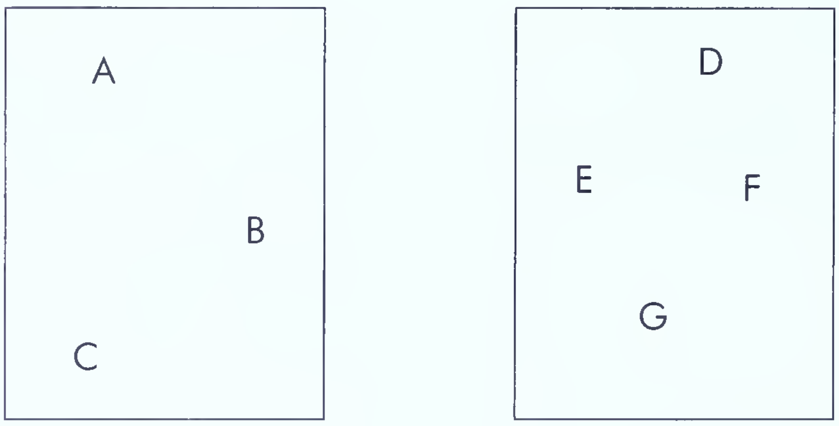

A. Head scarp of a slump in glacial sediments near New Albany, Bradford County. Tire tracks in the driveway indicate the age of the most recent movement.
B. Rockslide and debris slide near Fairfield Center, Lycoming County. The attitude of the bedrock can be seen behind the hood of the truck.
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DEDICATION

John Peter Wilshusen
1930–1991

For Pete, who pioneered the use of bicycles as field vehicles for landslide inventory on roadless portions of Pine Creek Gorge, with thanks.

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(in pocket)

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LANDSLIDE SUSCEPTIBILITY IN THE WILLIAMSPORT 1- BY 2-DEGREE QUADRANGLE, PENNSYLVANIA

by

Helen L. Delano and J. Peter Wilshusen[1]

ABSTRACT

The Williamsport 1- by 2-degree quadrangle includes major portions of the Deep Valleys, Glaciated High Plateau, and Glaciated Low Plateau sections of the Appalachian Plateaus physiographic province and of the Appalachian Mountain section of the Ridge and Valley province. Sedimentary bedrock, Cambrian to Pennsylvanian in age, ranges from largely undeformed, flat-lying rocks of the Plateau to strongly folded and faulted rocks of the Allegheny Front and Appalachian Mountains. Nearly 64 percent of the area is underlain by bedrock of the Upper Devonian and Lower Mississippian Lock Haven, Catskill, and Huntley Mountain Formations, which are interbedded sandstones, siltstones, and shales. Approximately half the area is covered by Wisconsinan glacial deposits; most of the remaining area has colluvial and residual soils of varying thicknesses.

Landslide susceptibility of slopes within the Williamsport area ranges from very high to very low. Landslide types described within the area are slumps and slump-earthflows, debris slides, debris flows, debris avalanches, rockfalls, rockslides, and combinations of these types. All types of slides are most likely to occur in areas of shaly, laterally variable bedrock. Debris avalanches, slides, and flows typically involve colluvial soils, whereas slumps and slump-earthflow composite slides are more likely to occur in glacially derived sediments.

A partial inventory of more than 1,300 recent and older landslides of several types and detailed analysis of 13 slides representative of slide types and geology across the area are the basis for the determination of three zones: high, moderate, and low susceptibility to landsliding. A 1:250,000-scale map of landslide susceptibility (Plate 1) is based on bedrock and surficial geology related to known landslide occurrences and is divided into the three zones.

The high-susceptibility zone includes areas of glacial-lake clay deposits in the stream valleys of the northern part of the quadrangle, steep colluvium-covered slopes in the dissected plateaus, the folded and fractured rocks at the Allegheny Front, and accumulations of colluvium and glacial deposits on bedrock dip slopes in the Appalachian Mountains. The moderate-susceptibility zone is made up of moderately steep colluvial slopes in the Plateau, areas of thick till and other glacial sediments, ancient debris-flow deposits, and unreclaimed strip-mine areas. The remaining area of uplands in the Plateau and the generally low-relief areas of glaciated plateaus and carbonate valleys are considered to have generally low susceptibility to landsliding, although local conditions may lead to slope instability almost anywhere.

The overall density of landslide occurrence in the Williamsport area is low, certainly when compared to very high susceptibility areas such as the greater Pittsburgh area. Locally severe landslide conditions and the wide variety of types of landslide problems demonstrate the need for awareness of the hazard.

INTRODUCTION

The subject of this publication is landslide susceptibility in the Williamsport, Pa. 1- by 2-degree quadrangle (Figure 1). The study area comprises one hundred twenty-eight 7.5-minute quadrangles, an area of approximately 7,150 square miles, in the north-central part of the state adjacent to New York State. Included are all of Tioga, Lycoming, Bradford, and Sullivan Counties and portions of Potter, Cameron, Clinton, Centre, Union, Northumberland, Montour, Columbia, Luzerne, Wyoming, and Susquehanna Counties. The map area extends from 41 to 42 degrees north latitude and from 76 to 78 degrees west longitude.

This investigation of regional landslide susceptibility is a continuation of work done by the U.S. Geological Survey (USGS) covering a large portion of the Appalachian Plateau in the eastern United States. Slope-stability studies were undertaken by the USGS from Alabama to western Pennsylvania between 1976 and 1984. Publications resulting from these studies and other work relevant to landslides in Pennsylvania include Briggs and Kohl (1975), Briggs and others (1975), Davies and others (1978), Freedman (1977), Gray and others (1979), Hackman and Thomas (1978), Hamel (1980), Pomeroy (1978, 1980, 1981, 1982a,

[1]Deceased.

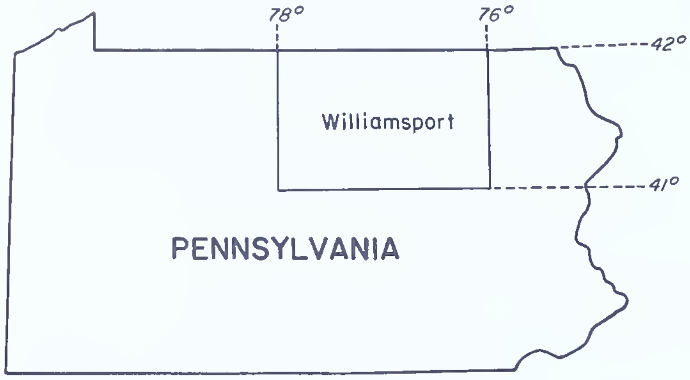

Figure 1. Location of the Williamsport 1- by 2-degree quadrangle.

1982b, 1983, 1986), and Pomeroy and Davies (1975, 1979).

The purpose of the present investigation was to map and describe those areas in which the potential for landslide occurrence should be considered for any construction or development, to describe in detail the types of landslides characteristic of the area, and to provide a partial inventory of known landslide occurrences.

This report is directed to those who are responsible for land use decisions and is concerned primarily with one of the geologic factors relating to land use planning. Other factors, in addition to landslide susceptibility, are rock and soil types, availability of economic mineral deposits, and potentials for flooding and ground subsidence.

There are many sources of information about various aspects of landslides. Some of them are Alger and Brabb (1985), Fleming and Taylor (1980), Radbruch-Hall and others (1982), Sharpe (1938), Terzaghi (1950), Turner and Shuster (1996), and U.S. Geological Survey (1982).

DEFINITION OF LANDSLIDES

Landslides, earlier defined (Eckel, 1958) as the downward and outward movement of slope-forming materials—natural rock, soils, artificial fills, or combinations of these materials, are more specificially designated today as the group of slope movements wherein shear failure occurs along a specific surface or combination of surfaces (Schuster and Krizek, 1978).

CLASSIFICATION

In this report, the classification used is that established by Varnes (1978), which is based on both an extension of the work of earlier investigators and new work on a broad spectrum of landslide analyses. Under this system, all slope movements are categorized by movement type, such as falls, topples, slides, and flows. These types of movement are subdivided according to material type and named as shown in Table 1. In the Williamsport map area, the most common types of slope movement are earth and debris slumps, debris slides, debris flows, rockfalls, rockslides, and combinations of these types. Debris avalanches, a special case of rapid debris slides, also appear to be common, as indicated by hillside scars and bruised trees, but none were observed in action to verify that there was extremely rapid movement of material.

Varnes abandoned the term "landslide" as imprecise when used as a general term, and substituted "slope movement" to include instances that do not involve true sliding. The general term "landslide" is well established in popular and technical usage, however, and its informal usage by many earlier workers (Coates, 1977) will be continued in this report.

METHOD OF STUDY

An inventory of landslides in selected parts of the map area was conducted by the authors, who used field investigation, aerial-photographic analysis, field work of other geologists from the Pennsylvania Bureau of Topographic and Geologic Survey doing geologic mapping and groundwater studies in the area, the experience record of the Pennsylvania Department of Transportation (PennDOT) and Department of Environmental Protection (formerly Department of Environmental Resources) and of local offices of the U.S. Department of Agriculture Soil Conservation Service, inquiries to township and municipal officials, and the cooperation of geoscience department staff members at Bloomsburg and Mansfield Universities.

The landslide inventory based on aerial photographs included a detailed examination of black-and-white stereo pairs (at a scale of approximately 1:20,000), most of which were taken in 1965, 1967, and 1969, and some of which were taken in 1971, 1973, and 1978. These photographs, which were used to prepare the 7.5-minute topographic quadrangle map series and their photorevisions, gave better ground detail for landslide interpretation than did higher altitude black-and-white or color infrared photographs. The aerial-photographic inventory covered approximately 63 percent of the study area (81 of the 7.5-minute quadrangles). The areas covered by the inventory are representative of the whole Williamsport quadrangle and include portions of all of the geologic and physiographic divisions in the area. The aerial-photographic interpretation was combined with field investigations to verify types of identified landslide occurrences. Field investigations were done from spring 1982 through fall 1983, and the aerial-photographic inventory continued through early summer 1984.

Field work also included detailed descriptions, measurements, and analyses of 13 representative land-

Table 1. *Classification of Appalachian Slope Movements*

(Modified from Varnes, 1978)

	Material type		
		Engineering soil	
Movement type	Bedrock	Predominantly coarse; can include fragments up to boulder size	Predominantly fine
Fall	Rockfall	Debris fall	Earth fall
Topple	Rock topple	Debris topple	Earth topple
Slide			
Translational	Rock block slide		Earth block slide
	Rockslide	Debris slide[1]	
Rotational	Rock slump	Debris slump	Earth slump
Flow		Debris flow[1]	Earthflow Mudflow
Creep	Rock creep	Debris creep	Earth creep
Composite	Combinations of the above		

[1]Can include debris avalanche, which is an extremely rapid (10 feet per second or more) movement of debris.

slides from selected areas. These data are given in the section "Landslide Types and Occurrence."

Because glacial-lake sediments (lake clays) are interpreted to be at the roots of many slides north of the glacial border, two large undisturbed samples, approximately 1 cubic foot each, were taken from deposits in the field area and sent to the USGS laboratory in Denver, Co., for engineering tests. The results of this testing are contained in unpublished files at the Pennsylvania Bureau of Topographic and Geologic Survey in Harrisburg.

The inventory shows more than 1,300 landslides of various historic and prehistoric ages in an area of somewhat more than 7,100 square miles. This is a relatively small number of occurrences when compared to areas in southwestern Pennsylvania where landslides have been mapped. For example, 2,000 landslides were identified in Allegheny County (see Figure 2 for county locations), an area of 728 square miles, by Pomeroy and Davies (1975), and more than 10,000 were identified (Pomeroy, 1978) in Washington County (see Figure 2), an area of 857 square miles. However, a significant number of unstable slopes occur within the Williamsport map area, in sufficient quantity to warrant careful attention when land use decisions are being made.

Considering the relationships of all landslide occurrences to their respective geologic and topographic conditions allows us to establish a set of criteria to use in judging under which circumstances landsliding may occur and to rank these so that risk zones can be mapped. These zones are shown on a 1:250,000-scale base map (Plate 1) that includes the locations of identified landslide occurrences. This map information concerning the potential for slope movement allows a planner or engineer to identify areas where detailed analysis of the site for slope stability should be included in development plans.

For each identified slide, data on landslide type, age, size, slope steepness and azimuth, and bedrock and surficial geology were compiled. These data are tabulated and included with reduced copies of the 7.5-minute quadrangle maps showing slide locations in the appendix. The analysis of the inventory data is discussed in the sections "Landslide Types and Occurrence" and "Factors That Affect Landsliding."

ACKNOWLEDGMENTS

The authors appreciate the assistance provided by other geologists in the identification and interpretation of landslide occurrences, as well as the cooperative efforts of local government officials and personnel from PennDOT and the U.S. Soil Conservation Service who pointed out landslides to us that had not been previously identified. Particular recognition is given to W. D. Sevon, Pennsylvania Bureau of Topographic and Geologic Survey, and Duane D. Braun, Bloomsburg State University, both of whom were doing surficial geologic studies in portions of the area, as well as to Jon D. Inners, Pennsylvania Bureau of Topographic and Geologic Survey, who has done recent geologic mapping in the southeast portion of the area. These three people aided this study through field reviews of work in progress and through sharing the results of their field work.

Alan R. Geyer, former chief of the Environmental Geology Division, Pennsylvania Bureau of Topographic and Geologic Survey, guided the project throughout its development, and Russell H. Campbell, USGS, Reston, Va., served as Project Officer for the study under a USGS grant (Agreement no. 14-08-0001-A-0075), leading cooperative efforts during its early stages.

Appreciation is also expressed to Roger W. Nichols, USGS, Denver, Co., who conducted laboratory tests of landslide-related samples from the project area.

John S. Pomeroy, USGS, Reston, Va., who conducted landslide susceptibility studies in adjacent areas of Pennsylvania to the west and southwest, generously shared the results of his mapping and the field methods developed during his work. We are also grateful for his critical review of the manuscript and many helpful suggestions.

GEOLOGIC SETTING

PHYSIOGRAPHY

A physiographic province is a region of consistent geologic structure in which the surface pattern of landforms developed on the structure differs significantly from that of adjacent areas. Portions of seven physiographic provinces occur in Pennsylvania (Fenneman, 1938), and two of these are represented in the Williamsport map area—the Ridge and Valley province and the Appalachian Plateaus province. Each province is subdivided into sections (Figure 2). This report involves the Deep Valleys Section, the Glaciated High Plateau section, and the Glaciated Low Plateau section of the Appalachian Plateaus province and the Appalachian Mountain section of the Ridge and Valley province. A small portion of the Allegheny Plateau section of the Appalachian Plateaus province is in the southwestern corner of the map area.

Differences in topography and geologic structure from one physiographic section to another play a significant part in landslide susceptibility and distribution and, therefore, are important to the designation of susceptibility zones. The general characteristics of each major physiographic division for this report area are shown in Table 2.

Appalachian Plateaus Province

In the Deep Valleys section, elevations within the Williamsport map area range from 560 feet at Torbert on the Jersey Shore 7.5-minute quadrangle (see Figure 19) to 2,570 feet near Cobb Hill on the Sweden Valley 7.5-minute quadrangle (see Figure 19). This section has 2,010 feet of topographic relief and is characterized by broad-topped ridges, steep valley walls, and narrow stream valleys, resulting from a deeply incised angulate and rectangular drainage pattern. Local relief exceeds 1,000 feet along many of the streams. Steep slopes (Figure 3) are typically 75 percent or greater, showing as very closely spaced contours on maps having a 20-foot contour interval. Distal tributary streams have steep gradients and relatively straight courses, whereas intermediate and large streams such as Kettle Creek, the West Branch of the Susquehanna, and the lower reaches of Pine Creek have more meandering courses. Erosion along these meanders can be a significant triggering mechanism for landslides.

Of necessity, highway and railroad systems in this physiographic section generally follow the main stream system, crowded along narrow valley floors and valley sides. As a result, maintenance costs related to debris slides and rockfalls are high, and a number of narrow areas, exemplified by stretches of Pa. Route 44 along Pine Creek, require constant vigilance.

The Glaciated High Plateau section lies to the north and east of the Deep Valleys section (Figure 2). Elevations within this section in the Williamsport map area range from 720 feet along Bowman Creek in Wyoming County (Noxen quadrangle) to 2,560 feet near Cobb Hill in Potter County. The landscape has been modified by continental glaciation, and slopes are typically less steep than in the Deep Valleys section. This area includes the drainage divide between streams of the Deep Valleys section, which flow north and west to the Allegheny River and south to the West Branch Susquehanna River, and the north-, east-, and southeast-flowing streams of the adjoining Glaciated Low Plateau section, which flow to the North Branch Susquehanna River. Local relief is typically 500 to 900 feet. Some valley bottoms are flat and moderately wide, and many contain sediments that were deposited in glacial lakes. These deposits and colluvium on the lower slopes are involved in many slope failures in this section.

The Glaciated Low Plateau section covers the northeastern portion of the map area (Figure 2). Elevations within the map area range from 600 feet on the Susquehanna River at Vosburg (Meshoppen 7.5-minute quadrangle) (see Figure 19) to 2,200 feet on Mehoopany Mountain on the same quadrangle. The 1,600 feet of relief in this section is characterized by a more gentle topographic expression than in the sections to the west. Streams are not as deeply incised and valley walls are less steep than in the Deep Valleys and Glaciated High Plateau sections. In spite of the more subdued topography, there are numerous slope failures, which occur primarily in unconsolidated deposits of clay, sand, and gravel of glacial origin.

A dendritic stream network carries most of the runoff into the North Branch Susquehanna River. Fig-

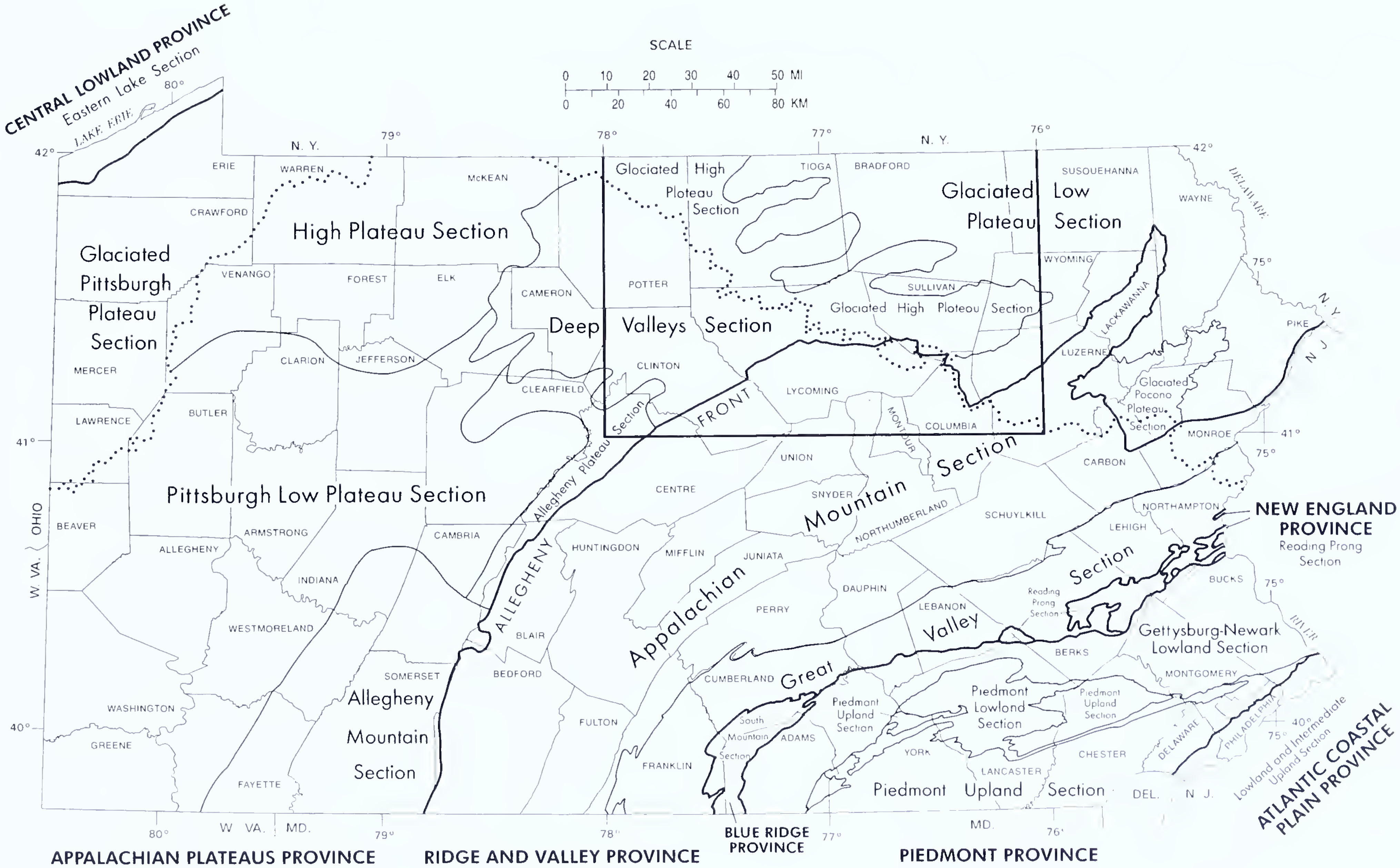

Figure 2. Physiographic provinces of Pennsylvania (Sevon, 1996) and the location of the report area. The dotted line represents the Late Wisconsinan glacial border.

Table 2. *Characteristics of Major Physiographic Sections in the Williamsport 1- by 2-Degree Map Area*

(After Sevon, 1996)

	Appalachian Plateaus province
Deep Valleys section	A deeply dissected plateau having structure characterized by open folds in gently dipping bedrock. Hilltops are broad to narrow, capped by resistant sandstone and conglomerate, and have adjacent deep, steep-sided, narrow valleys.
Glaciated High Plateau section	Upland having broad to narrow, rounded to flat, elongate hilltops and deep to shallow valleys. Bedrock structure consists of moderate-amplitude open folds. Hilltops are capped by resistant sandstone and conglomerate. Local relief[1] is less than that in the Deep Valleys section. Valleys commonly contain glacial and glaciolacustrine deposits and many have flat floors.
Glaciated Low Plateau section	Area having rounded hills and shallow stream valleys and moderate to low local relief[1]. Some buried valleys have wide, flat floors. Bedrock is very gently folded sandstone, siltstone, and shale. Topographic relief is subdued by the effects of continental glaciation.
Allegheny Plateau section	Rounded to flat uplands having shallow to moderately deep, angular to rounded valleys. Local relief[1] is moderate to high. Bedrock is nearly flat-lying sandstone, siltstone, shale, conglomerate, and some coal.
	Ridge and Valley province
Appalachian Mountain section	Sinuous, narrow ridges and valleys having tightly folded and faulted sequences of sandstone, conglomerate, quartzite, shale, and limestone. Resistant quartzite and conglomerate underlie the ridges, and less resistant sandstone, shale, and limestone make up the valleys. Structural deformation along the high escarpment of the Allegheny Front is more intense than elsewhere in the section.

[1]Local relief: 0 to 100 feet, very low; 101 to 300 feet, low; 301 to 600 feet, moderate; 601 to 1,000 feet, high; >1,000 feet, very high. (Relief categories listed here for Pennsylvania do not necessarily apply to other states or countries.)

ure 4 is a scene typical of the Glaciated Low Plateau section showing a meander of North Elk Run near Mansfield in an open, unforested landscape. Although the transportation network is not as restricted as it is in the Allegheny Mountains, roads and railroads are commonly in close proximity to streams. This combination of transportation routes and stream erosion in conjunction with glacial deposits commonly leads to debris slides and slumps. In addition, rockfalls are common in cuts along the deeper valleys of the North Branch Susquehanna River and its tributaries.

A small part of the Williamsport map area (in the southwest corner) is in the Allegheny Plateau section of the Appalachian Plateaus province. Elevations here range from approximately 900 feet along Beech Creek in the Snow Shoe SE quadrangle (Figure 19) to 2,320 feet in Beech Creek Township on the Snow Shoe NE quadrangle. Local relief is low to moderate, and the landscape consists of rounded to flat uplands and shallow to moderately deep valleys developed on nearly flat-lying bedrock. Much of the upland area has been strip-mined for coal, and slope failures occur in the disturbed areas.

Figure 3. Kettle Creek valley is typical of the steep-sided stream valleys in the Deep Valleys section of the Appalachian Plateaus province.

Figure 4. North Elk Run (Mansfield 7.5-minute quadrangle) flows through a terrain representative of the Glaciated Low Plateau section. Stream action has triggered landslides in the unconsolidated glacial clay, sand, and gravel along the valley sides. In the background, the stream flows on flat-lying shale and siltstone bedrock.

Ridge and Valley Province

The Appalachian Mountain section of the Ridge and Valley province is markedly different from the Appalachian Plateaus province. In most places, the Allegheny Front stands as an escarpment of demarcation between the two provinces. The distinction between the provinces is based primarily on geologic structure in that bedrock units south of the Front are strongly folded and faulted, in contrast to gently folded to flat-lying and less faulted strata to the north.

The Appalachian Mountain section occurs across the southern portion of the report area. Elevations range from 440 feet on the West Branch Susquehanna River southeast of Milton (Milton 7.5-minute quadrangle) (see Figure 19) to 2,170 feet on White Deer Ridge north of Carroll (Carroll 7.5-minute quadrangle) (see Figure 19), making the topographic relief 1,730 feet. The Appalachian Mountain section can be subdivided based on variations in underlying geologic structure, which influence the occurrence and types of landslides. The largest subdivision is characterized by linear ridges and parallel, narrow valleys in the southwestern part of the section. These ridges and valleys give way to more open valleys and lower, more widely separate hills in the eastern part of the section. The open, rolling hill terrain is punctuated in the extreme eastern part of the section by two closely opposed, narrow hairpin ridges forming the southwest portion of the Northern Anthracite region.

Figure 5 shows a landscape typical of the structurally folded, linear ridges and valleys of the Appalachian Mountain section. Generally forested ridges separate cultivated valleys. Landslides occur mostly on lower slopes in colluvium and along stream banks. Large, unvegetated boulder fields (Figure 5) occur locally on the mountainsides. Although their outlines are suggestive of debris slides, they are stable slopes if left undisturbed, due to a composition of interlocking, angular boulder fragments that have weathered from the ridge above and accumulated as boulder fields containing very little fine-grained interstitial rock material and soil (Figure 6). The boulder fields are free draining and have little opportunity for a buildup of pore pressure. These striking hillside features are believed to have developed in a periglacial climate near the edge of a continental ice sheet. The lower slopes of some ridges are mantled with thick clay-rich colluvium that is prone to sliding if disturbed.

Eastward from Montoursville and Muncy, structural deformation of bedrock is less evident, producing a landscape of lower topographic relief dominated by rolling hills where farming is a major land use. Slope instability in this subdivision of the Appalachian Mountain section is less of a problem than elsewhere in the report area.

The third subdivision, the southwest extension of the Northern Anthracite region, extends from Nanticoke to Knob Mountain northwest of Berwick. Here, highway and railroad transportation routes are crowded along a narrow river valley (Figure 7) below steep slopes. Although this subdivision is a small part of the project area, it is important with respect to landslide susceptibility. The major river cutting through a large bedrock fold and the later deposition of thick, unconsolidated glacial deposits produced a number of poten-

Figure 5. The north slope of Bald Eagle Mountain and the valley of the West Branch Susquehanna River exemplify the Appalachian Mountain section of the Ridge and Valley province. The unforested boulder field in the background is suggestive of a debris slide, but boulder fields such as this are presently stable.

tially unstable sites. The bedrock units in the mountain ridges dip toward the river valley along much of its course, which further increases the landslide potential.

GEOLOGY

Bedrock

Twenty-eight geologic formations make up the bedrock units that underlie the Williamsport 1- by 2-degree map area. Each of these formations is described in Table 3. The reader is referred to the *Geologic Map of Pennsylvania* (Berg and others, 1980) for the location of formation boundaries at a scale of 1:250,000, and to *Engineering Characteristics of the Rocks of Pennsylvania* (Geyer and Wilshusen, 1982) for information on the characteristics of the rocks.

Bedrock geology is significant to the determination of landslide susceptibility in a number of ways. First, the position and characteristics of topographic features are related to rock type and geologic structure. Second, the different types of soil cover are dependent upon weathering characteristics of local bedrock units. Therefore, the geologic formations and their characteristics and products of weathering are important components in the designation of mappable factors of landslide susceptibility. These characteristics are outlined in Table 3 and discussed for each landslide type in the section on "Factors That Affect Landsliding."

The lithology of the formations, all of which are sedimentary rock, includes sandstone, conglomerate,

Figure 6. Coarse boulder colluvium forming a boulder field on a 42-degree (90-percent) slope in the Appalachian Mountain section of the Ridge and Valley province. Interlocking angular boulders, having no appreciable amount of fine rock fragments or fine-grained soil, form a freely draining slope that is stable if left undisturbed.

Figure 7. Shickshinny Mountain and the Susquehanna River are representative of the terrain in the southwestern portion of the Northern Anthracite region. The steep slope bordering a major stream valley and the glacial deposits on the lower slopes are a setting for potential landslides. Landslide occurrences are often related to highway and railroad construction in constricted areas.

shale, siltstone, mudstone, and limestone, and sandstone underlies the most extensive areas. Sandstone units have a variety of mineral compositions, textures, grain sizes, origins, and depositional features. No igneous or metamorphic rocks crop out in the area. The geologically older formations of the thick sequence (up to 25,000 feet) of sedimentary rock occur along the southern part of the map area, and progressively younger formations exist over the largest portion of the area, north and west of Lock Haven and Williamsport. Depositional history and stratigraphic relationships of these formations are discussed in a number of other publications (for example, Faill and others, 1977a; Inners, 1981; and Sevon and Woodrow, 1981) but are not related directly to landslide susceptibility.

Structural deformation of the rock formations in the map area has resulted in folded and faulted bedrock units broken by a system of joints and other fractures. Fractures are open and readily delineated near the surface and become progressively tighter with increasing depth. Orientation and spacing of the fractures vary throughout the area depending upon rock type and structure. Bedrock weathering begins with rock fragments breaking away from the parent material along bedding plane fractures and joint systems that are at angles to the bedding plane. Dislodged rock fragments then break down further, providing raw material for the production of finer grained soil. Rock alone, a combination of soil and rock, or soil alone can be susceptible to landsliding on unstable slopes.

Detailed geologic maps are available for some portions of the Williamsport map area. These include Colton (1963, 1967, 1968), Colton and Luft (1965), Faill (1979), Faill and others (1977a, 1977b), Inners (1978, 1981, 1997), Taylor (1977), Way (1993), and Wells and Bucek (1980).

Surficial Material

The term "soil" is used in its engineering sense in this report. It includes all weathered rock, rock fragments, gravel, sand, silt, clay, and organic material overlying sound bedrock. Many soils in the area are products of weathering from underlying bedrock and have been transported for only short distances, if at all. Others are mobile alluvial soils developed along stream channels or soils that have been generated and transported by glacial activity. Three classes of soil are present: residual and colluvial, alluvial (transported by streams), and glacial.

Approximately half of the study area was glaciated during the Wisconsinan glacial advances, resulting in the dominance of glacial soils below higher elevations in the northern and eastern portion of the map area (Figure 8). The glacial soils are the most susceptible of the three soil classes to landsliding on relatively gentle slopes. Residual and colluvial soils are dominant in the southwest portion of the map area, particularly as deposits of colluvium on hillsides, and are susceptible to landsliding during periods of heavy precipitation. Alluvial soils occupy stream-valley floors across the entire area and are least susceptible to landslides except for some stream-bank failures. Contacts between the three groups of surficial deposits are gradational, so that glacial soils blend into residual and colluvial soils and alluvial soils grade from both of the other classes.

Glacial soils are characterized by sand, silt, clay, and rounded to subangular cobbles and boulders. In till deposits, these components are thoroughly mixed, and in other types of deposits, they are segregated, and sand, clay, or cobbles are locally dominant. Where clay is dominant, as in scattered, ancient glacial-lake deposits, the susceptibility to landsliding is high.

Table 3. *Bedrock Characteristics in the Williamsport Map Area*

Age	Geologic formation and map symbol[1]	Principal lithologies	Bedding	Fracture pattern	Structure	Products of weathering
Pennsylvanian	Allegheny and Pottsville Formations, undivided IPap	Sandstone, shale, and some coal.	Variable; fissile and thin-bedded to massive.	Variable; closely spaced in fine-grained beds, widely spaced in sandstone.	Gently dipping in broad, open folds.	Variable; stony colluvial soil on sandstone; less stony soil on shale.
	Llewellyn Formation IPl	Sandstone, siltstone, shale, conglomerate, and numerous anthracite coal beds.	Well-developed, variable; thin in shale to massive in sandstone and conglomerate.	Moderately spaced, blocky pattern.	Gently to steeply dipping; tightly folded and faulted.	Variable; sandstone and conglomerate weather to stony soil; shale produces a fine-grained soil having small rock fragments.
	Pottsville Formation IPp	Predominantly sandstone and conglomerate and subordinate shale, siltstone, limestone, underclay, and coal.	Well-developed, thin to thick, crossbedding common.	Well-developed in regular pattern; widely to moderately spaced.	Gently dipping in broad, open folds in most of outcrop area; steeply dipping in tight folds in the southeast.	Stony soil and boulder colluvium.
Mississippian	Mauch Chunk Formation Mmc	Shale, siltstone, and sandstone and subordinate limestone and conglomerate.	Moderately well bedded; generally thin and flaggy.	Abundant; regularly spaced joint pattern.	do.	Weathers to a fine-grained clayey soil having rock fragments; commonly covered by boulder colluvium from adjacent units.
	Burgoon Sandstone Mb	Sandstone and local shale interbeds; intermittent conglomerate at base.	Well-developed, medium to thick beds. Sandstone commonly forms a dominant cliff.	Blocky pattern; irregular, steeply dipping joint surfaces.	Gently dipping in broad, open folds.	Boulder colluvium and stony soil.
	Pocono Formation Mp	Sandstone, minor siltstone, and prominent interbedded conglomerate.	Well-developed, thin to thick, crossbedding common.	Well-developed joints, moderately to closely spaced joint pattern.	Steeply dipping in tight folds.	do.
Mississippian and Devonian	Huntley Mountain Formation MDhm Rockwell Formation MDr	Sandstone, argillaceous sandstone, and a few shale interbeds.	Well-developed, thin to medium, flaggy.	Well-developed along steeply dipping joints and bedding-plane openings.	Gently dipping in broad, open folds.	Flaggy colluvium and stony soil.
Devonian	Catskill Formation Dck	A thick, complex unit consisting of shale, siltstone, sandstone, and conglomerate.	Well-developed, thin to thick, units are commonly crossbedded.	Well-developed and closely spaced; generally a blocky or platy pattern.	Gently dipping in broad, open folds in most of the outcrop area; steeply dipping in tight folds in the southeast.	Variable, depending on lithology. Shale units weather most rapidly, producing a fine-grained soil having chippy rock fragments. Sandstone and conglomerate in ridges produce a stony colluvial soil.
	Lock Haven Formation Dlh	Interbedded sandstone, siltstone, claystone, and thin conglomerate.	Thin to medium, well-developed.	Well-developed along near-vertical fractures and bedding-plane openings.	Flat-lying to gently dipping.	Stony soil having tabular rock fragments.

Table 3. *(Continued)*

Age	Geologic formation and map symbol[1]	Principal lithologies	Bedding	Fracture pattern	Structure	Products of weathering
Devonian *(continued)*	Trimmers Rock Formation Dtr	Sandstone, siltstone, and shale interbeds.	Well-developed, medium, flaggy.	Well-developed; steeply dipping fractures and bedding-plane openings.	Flat-lying to steeply dipping.	Sandy soil having numerous rock fragments.
	Brallier and Harrell Formations Dbh	The Brallier is interbedded siltstone and shale. The Harrell is a silty, sometimes limy, fissile shale.	Well-developed, planar, thin to fissile.	Irregular, steeply dipping fractures and bedding-plane openings.	Steeply dipping to flat-lying.	Shale-chip rubble that weathers further to fine-grained, clayey soil.
	Hamilton Group Dh	Siltstone and shale interbedded with sandstone. Some discontinuous limestone beds.	Well-developed, thin to fissile, commonly flaggy.	Well-developed; closely spaced joints and bedding-plane fractures.	Generally steeply dipping, some flat-lying.	Sandy soil having numerous blocky rock fragments.
	Onondaga and Old Port Formations Doo	Limestone, calcareous shale, chert, and some claystone.	Well-bedded, thin to massive, commonly flaggy.	Steeply dipping joints and bedding-plane fractures, blocky to tabular pattern.	Generally steeply dipping, some moderate dips.	Variable; generally stony soil having shale-chip rubble slowly disintegrating to clayey soil.
Devonian and Silurian	Keyser and Tonoloway Formations DSkt	Nodular limestone underlain by laminated limestone.	Thin-bedded in lower part, grading upward to massive.	Joints and bedding-plane openings intersect at near right angles; blocky to tabular pattern.	Generally steeply dipping.	Clayey soil having small rock fragments.
Silurian	Wills Creek Formation Swc	Shale having discontinuous limestone and sandstone interbeds. Siltstone in lower part.	Fissile to thin-bedded.	Abundant, closely spaced fractures.	Steeply dipping; structurally deformed.	Shale-chip rubble that weathers to a clayey soil having shaly fragments.
	Bloomsburg Formation Sb Bloomsburg and Mifflintown Formations, undivided Sbm	Shale, siltstone, sandstone, and some calcareous claystone. Some limestone in Mifflintown.	Fissile to thin-bedded; some is medium-bedded.	Seamy, platy pattern; irregular and closely spaced.	Flat-lying to steeply dipping; structurally deformed.	Small shale and sandstone fragments near rock weather to a silty soil having scattered rock fragments.
	Clinton Group Sc	Shale having hard ferruginous sandstone interbeds.	Well-bedded, thin in shale to medium and thick in sandstone.	Well-developed, regular and closely spaced.	Generally steeply dipping; gently dipping at fold axes.	Silty to clayey soil having hard rock fragments from sandstone interbeds.
	Tuscarora Formation St	Tough sandstone and quartzite.	Well-bedded, medium to thick, commonly massive.	Abundant and well-developed; joints and bedding-plane fractures form a blocky pattern.	Variable; steeply dipping to flat-lying.	Generates rocky talus slopes, extensive boulder colluvium, and boulder fields.
Ordovician	Juniata Formation Oj	Siltstone, shale, and cross-bedded sandstone.	Well-bedded, thin to flaggy.	Regularly spaced joints and bedding-plane openings; blocky to tabular pattern.	do.	Colluvium and stony soil.
	Bald Eagle Formation Obe	Sandstone, some conglomerate, and interbeds of shale.	Well-bedded, thin to thick.	Poorly developed joints, blocky pattern.	Flat-lying to gently dipping; sometimes steeply dipping.	Boulder colluvium and stony soil.

Table 3. *(Continued)*

Age	Geologic formation and map symbol[1]	Principal lithologies	Bedding	Fracture pattern	Structure	Products of weathering
Ordovician *(continued)*	Reedsville Formation Or	Shale, siltstone, and fine-grained sandstone.	Thin.	Abundant, closely spaced fractures.	Variable; steeply dipping to moderately dipping and flat-lying.	Pencil-shaped shaly fragments from rock weathering deteriorate into a shale-chip silty soil.
	Coburn through Nealmont Formations Ocn	Limestone, shaly limestone, and calcareous shale.	Fissile to thin, commonly flaggy.	Well-developed platy to blocky pattern.	Gently dipping, flat-lying near fold axes.	Clayey soil having limestone fragments.
	Benner through Loysburg Formations Obl	Limestone, dolomitic limestone, argillaceous limestone, and dolomite.	Thin to thick, sometimes flaggy.	Variable pattern; blocky to platy, abundant and fairly regular.	Variable; steeply dipping to flat-lying.	do.
	Bellefonte Formation Obf	Dolomite having some interbedded sandstone and chert.	Well-developed, thick to medium.	Well-developed, regularly spaced blocky pattern.	Variable; steeply dipping to flat-lying; faulted.	Clayey soil having dolomite and chert fragments.
	Axemann Formation Oa	Limestone interbedded with dolomite.	Well-developed, thick to thin.	do.	Steeply dipping to flat-lying near fold axes.	Clayey soil having limestone and dolomite fragments.
	Nittany Formation On	Dolomite, sometimes sandy, and interbedded chert.	Generally well-developed, thick.	Variable, moderately developed.	Moderately dipping to flat-lying, faulted.	Clayey soil having dolomite and chert fragments.
	Stonehenge/Larke Formations Osl	Limestone having shaly interbeds and dolomite.	Well-developed, flaggy to thick.	Well-developed blocky to flaggy pattern.	Moderately to steeply dipping, faulted.	Clayey soil having limestone and dolomite fragments.
Cambrian	Gatesburg Formation €g	Interbedded units of dolomite, limestone, and sandstone.	Well-developed, thick to massive.	Well-developed blocky pattern.	Moderately dipping to flat-lying.	Clayey and sandy soil having rock fragments of various compositions (limestone, dolomite, and sandstone).

[1]Map symbols are the same as those used in the appendix and on *The Geologic Map of Pennsylvania* (Berg and others, 1980).

Figure 8. Major streams, selected towns, and distribution of glacial deposits in the Williamsport 1- by 2-degree area. The patterned area in the northeast section of the map is 25- to 50-percent covered with moderately thick glacial deposits. Some of these deposits are naturally susceptible to landsliding, and others are susceptible where the slopes are modified by construction activity.

Residual soils, which are formed from weathering of the rocks directly below them, are the most variable. Their nature generally closely reflects that of the underlying bedrock. Colluvial soils have been transported some distance downhill by soil creep, slope wash, or similar processes and accumulate near the base of a slope. On mountain slopes and ridge crests, residual and colluvial soils are generally coarse and stony, containing a high percentage of large rock fragments. Colluvial soils on mountain slopes are slide prone in many places. In open valleys, residual soils are typically finer grained and have varying proportions of smaller rock fragments. Because they have similar characteristics related to landsliding and can be difficult to differentiate, colluvial and residual soils are combined into one category for the purposes of this report.

Alluvial soils are also variable, depending upon the nature of bedrock and glacial deposits over which streams flow. Alluvial soils are generally comprised of sand, silt, and gravel and have angular to rounded cobbles and boulders.

In the classification of slope movement (Table 1), the three classes of soil described are placed into two categories. If a soil is predominantly composed of coarse material, it is debris; if it is predominantly composed of fine material, it is earth. A mudflow is wet enough to flow rapidly and is mainly fine material.

LANDSLIDE TYPES AND OCCURRENCE

DESCRIPTION OF TYPES

Seven types of landslide movement have been observed in the Williamsport map area. These types are as follows:

(1) Debris avalanche
(2) Debris slide

(3) Debris flow
(4) Rockfall and rockslide
(5) Slump
(6) Slump combined with debris flow or earthflow
(7) Composite landslide

The name and description of each type are based on an established classification (Varnes, 1978) (see Table 1). The principal criteria for identification are: (1) the mechanism of landslide movement; and (2) the nature of material that has moved. Most landslide movement can be classified as translational sliding, rotational sliding, or flow. Both types of sliding involve relatively undisturbed material moving over a surface or zone of shear displacement. Translational landslides move on a planar or gently undulating surface, whereas rotational landslides move on a concave-upward, curved surface of rupture. These categories are illustrated in Figure 9. Flow movement involves considerable internal distortion of the moving material, and can be thought of as similar to the movement of a viscous fluid. Falls involve detached material falling free, and topples involve rotation of the top of a block outward from the slope before it falls or slides. As in most artificial classification systems, these categories commonly grade into each other and can also occur in combination.

The nature of the material is also important in the identification of landslides. Varnes (1978, p. 24) used the following classification for landslide materials. Bedrock is hard or firm rock that was intact and in its natural place before the initiation of movement. Engineering soil (differentiated from agricultural soil) includes any loose, unconsolidated or poorly cemented aggregate of particles. It may have been derived from the weathering of rock nearby, or it may have been transported by water, wind, or slope processes to its present location. Engineering soil is classified according to its grain size. Debris is engineering soil consisting of 20 to 80 percent fragments larger than sand size (2 mm); fragments in debris can be quite large. Earth is engineering soil in which 80 percent or more of the fragments are sand sized or smaller.

Debris Avalanche

Debris avalanche (Figure 10) is the rapid downhill movement of a combination of soil and rock along a planar surface. The resulting scar is generally long and narrow, leaves a channel, or chute, on a hillside, and has an accumulation of debris at the toe. Debris avalanches are the result of rapid to extremely rapid movement at a rate greater than 10 feet per second. Although none were observed in motion to verify their

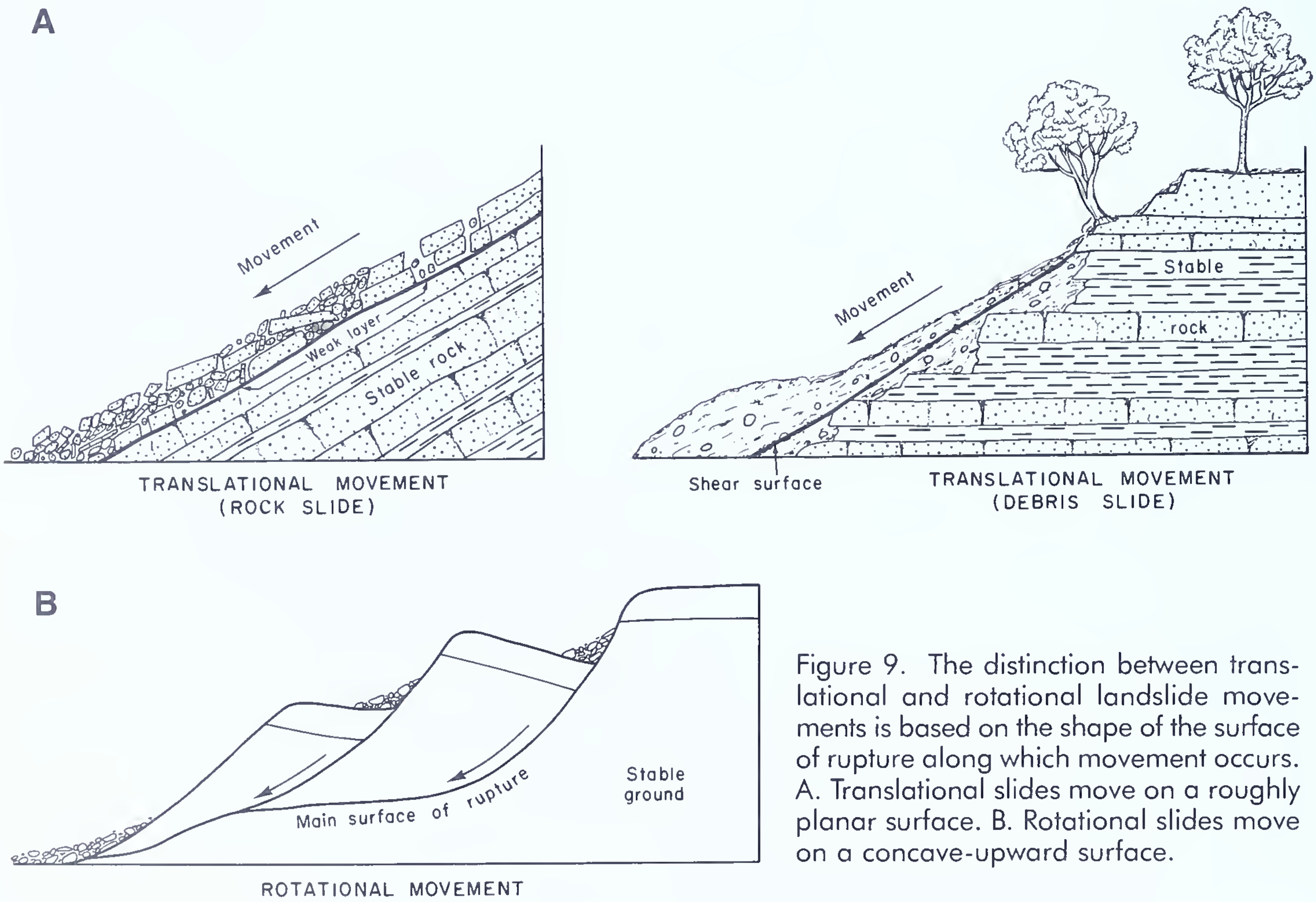

Figure 9. The distinction between translational and rotational landslide movements is based on the shape of the surface of rupture along which movement occurs. A. Translational slides move on a roughly planar surface. B. Rotational slides move on a concave-upward surface.

Figure 10. A debris avalanche, triggered by heavy rain, has left a long, narrow scar on a steep hillside and an accumulation of rocky debris along the stream at its toe. Regrowth of vegetation on the scar and stream erosion of the deposit at the toe will conceal evidence of this slide after several years. The site is at the Stevenson Dam on First Fork, just outside the western border of the Williamsport map area. Debris avalanches commonly occur in narrow valleys.

rapid speed, circumstantial evidence exists, consisting of scarred trees and the lateral extent of deposited material at the toe of the slope.

Debris Slide

Debris slide (Figure 11) is the progressive downhill movement of soil and rock debris, sometimes in a long and narrow channel, but not confined to that configuration. Displacement is along a roughly planar surface of rupture, as is the case with debris avalanches, but not necessarily having the continuous high rate of speed exhibited by the latter. Initial movement, through stress release, may be rapid, and slower, intermittent movement may occur over a period of time. In a debris slide, the moving mass generally breaks up into smaller and smaller parts as it moves downhill.

Debris Flow

Debris flow (Figure 12) is the downhill movement of soil and rock fragments advancing as a viscous fluid. Slip surfaces within the moving mass are generally not apparent because the mass is continually deformed during flow. Most debris flow involves water-saturated sediment moving relatively fast, and it may resemble wet concrete. The slow end of the debris-flow continuum is debris creep, which is more comparable to deforming putty on a tilted surface. Debris flow is commonly a part of composite landslides, the clay-rich material also serving as a lubricant on which overlying material moves.

Rockfall and Rockslide

Rockfall is the free fall of pieces of rock detached from a cliff face or near-vertical slope. As defined by Varnes (1978, p. 12), ". . . a mass of any size is detached from a steep slope or cliff, along a surface on which little or no shear displacement takes

Figure 11. An active debris slide along Kettle Creek in the Deep Valleys section that requires the frequent removal of material to maintain the road (out of the photograph) at the toe.

Figure 12. Debris flow in colluvium and residuum on sandstone and shale of the Catskill Formation in the Sinnemahoning Creek valley.

place, and descends mostly through the air by free fall, leaping, bounding or rolling."

Rockfall takes place in different forms that are dependent upon rock type and the direction and spacing of rock fractures, as well as the orientation of the fractures with respect to the cliff face. Rockfall from a shale slope, for example, will yield small fragments, whereas a medium-bedded sandstone having widely spaced joints and a structural bedding dip toward the rock face is more likely to yield large slabs. Falls of material other than rock are rare, but they can occur. A fall of material previously detached from the main rock mass is a debris fall, and earth fall is possible if a steep face of fine-grained material fails and sections fall.

A rockslide (Figures 9A and 13) is the downhill movement of detached rock fragments along a planar surface. In a block slide, the displaced material remains as a small number of intact blocks. If two or more planar surfaces of weakness intersect along a line that dips out of the slope, a wedge slide, movement of a wedge of material, may occur.

Slump

Slump (Figures 14 and 15) is rotational sliding in which the surface of rupture is a concave-upward shear surface or zone. The axis of rotation is horizontal and generally parallel to the trend of the slope on which failure occurs. The head of a slump tilts back into the slope and the toe characteristically rises, spilling out over undisturbed ground along a surface of separation (Figure 15). The least distortion of the sliding mass is at its head, whereas the greatest distortion is at the toe. Individual slumps commonly form segments of larger composite landslides or may exist by themselves as small discrete slope failures along a hillside. Slump can occur in rock or soil, but it is most common in uniform fine-grained material. The absence of planar weak surfaces such as bedding or fracture discontinuities allows development of the concave slip surface. Progressive slump failure occurs

Figure 13. Rockslide occurs intermittently along the bedding planes and joint surfaces of siltstone and shale in this wedge failure along U.S. Route 15 at Allenwood. Detached rock fragments regularly add to the mass of debris accumulating at the toe.

Figure 14. A small slump block that is part of a larger composite rockslide and debris slide on the Huntersville 7.5-minute quadrangle. The orientation of the originally upright trees clearly shows the rotational movement.

where the main mass of the slide moves down so far that the steep scarp is unsupported and the upper material slumps into the scar. This process can repeat many times, causing the failed area to grow upward to the limit of susceptible material.

Slump Combined With Debris Flow or Earthflow

The landslide deposit of a slump failure commonly continues past the toe of the curved surface of rupture and moves farther downslope as an earthflow or debris flow. Figure 16 is a schematic cross section of this type of movement, showing a slump scarp and a deposit extending as a debris flow along a surface of separation between undisturbed ground and the flow. Failure is by rotational sliding in the upper part of the slide, and grades into flow below the slump. A slump-earthflow in glacial till is illustrated in Figure 17.

Composite Landslide

A composite landslide is characterized by combinations of some of the six types listed above in a single occurrence. For example, slump or debris sliding may occur high on a hillside and trigger a debris avalanche, or debris slides and debris flows may generate rockfalls and debris falls when a moving toe approaches the top edge of a steep roadcut or embankment. Not uncommonly, slumps will occur along the head scarp of a debris slide after initial movement of the slide. A significant number of landslides in the report area are composite occurrences, involving several different types of movement.

OCCURRENCE

Landslides have been occurring in north-central Pennsylvania for a long time. Many old slides are believed to have been triggered in the Pleistocene by harsh climate conditions during the most recent ice age or by erosion by glacial ice or meltwater streams. Remnant evidence of prehistoric landslides, mostly in the western part of the map area, can be seen by stereoscopic examination of aerial photographs and by field examination. The age of the older slides that were identified, however, was not determined. A complicating factor in age determination is that landslides do not age uniformly. Some slides appear to heal in a relatively short time, as exemplified by the scar left from a debris avalanche, the deposit of which comes to rest in a stream bed. Vegeta-

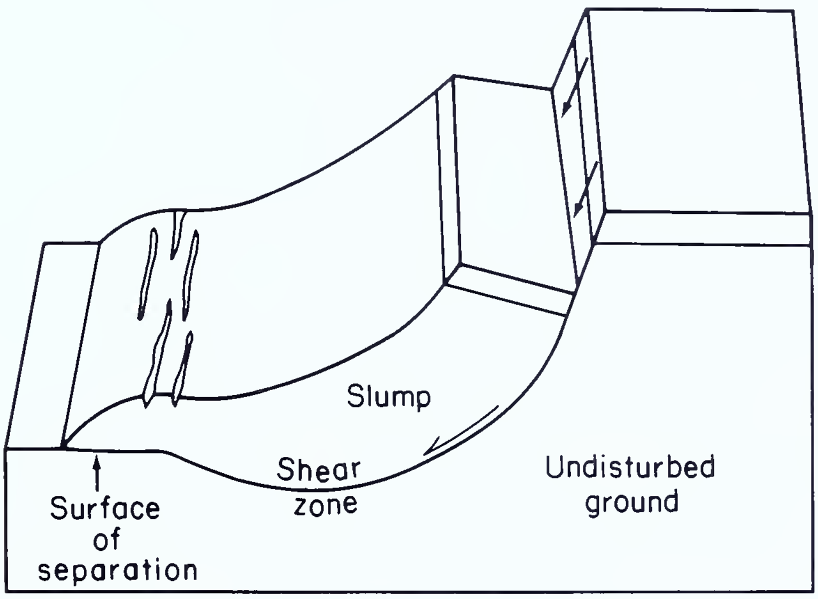

Figure 15. The mechanism of slump failure. The shear zone is concave upward. The head of the slide is tilted back toward the slope, and the material at the toe moves out and upward.

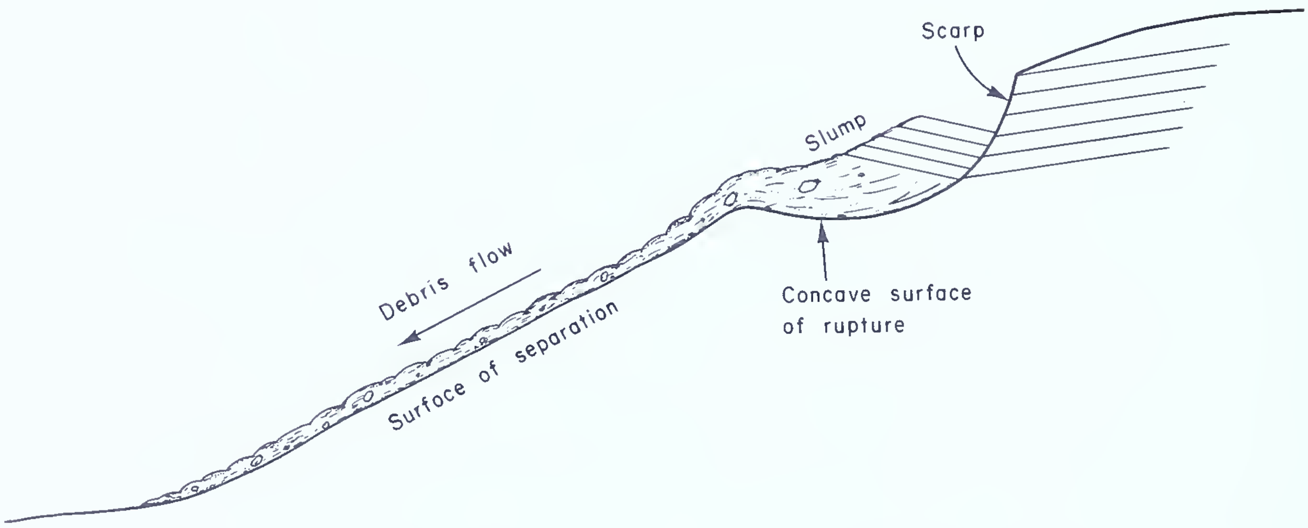

Figure 16. Schematic cross section of a combination of slump and debris flow.

Figure 17. Slump-earthflow in glacial till in a recent highway cut along U.S. Route 15 north of Mansfield.

tion and erosion soon hide the scar, leaving a nick in the ridge flank, and stream erosion carries away much of the deposit, leaving, perhaps, a deflected bend in the creek. On the other hand, evidence of a large, old composite landslide on a gentle slope in glacial deposits appears to remain over a long period of time, showing as a distinct area of hummocky topography having crescent-shaped scarp lines (Figure 18). In this report, the term "old" is used for any landslide that does not show evidence of recent movement. The age of an "old" landslide could range from tens to thousands of years. If there are indications of age that allow more precise dating, appropriate terminology will be used.

Although the age of the oldest slope failures identified was not established, it is, nevertheless, apparent that landsliding

Figure 18. Old slump in glacial-lake clay along North Elk Run west of Mansfield.

Table 4. *Factors That Influence Landslide Susceptibility*

Bedrock					Water		
Lithology	Structure	Soil	Topography	Weather	Groundwater	Surface water	Construction and mining
Strength Weathering characteristics Porosity Permeability Sequences of different lithologies Bedding characteristics	Joint orientation and spacing Bedding attitude Fault zone Intersecting joints	Clay content Thickness Drainage Glacial deposits Old landslide deposits	Slope steepness Slope orientation Concave slopes	Heavy rainfall Long-duration rainfall Rapid snowmelt Freeze-thaw cycles	High levels Rapid fluctuations of level Poor soil drainage Seeps and springs	Rapid runoff Streambank erosion New impoundments	Highway and railroad cuts and fills Clearing of vegetation Mine waste piles Mine and quarry highwalls

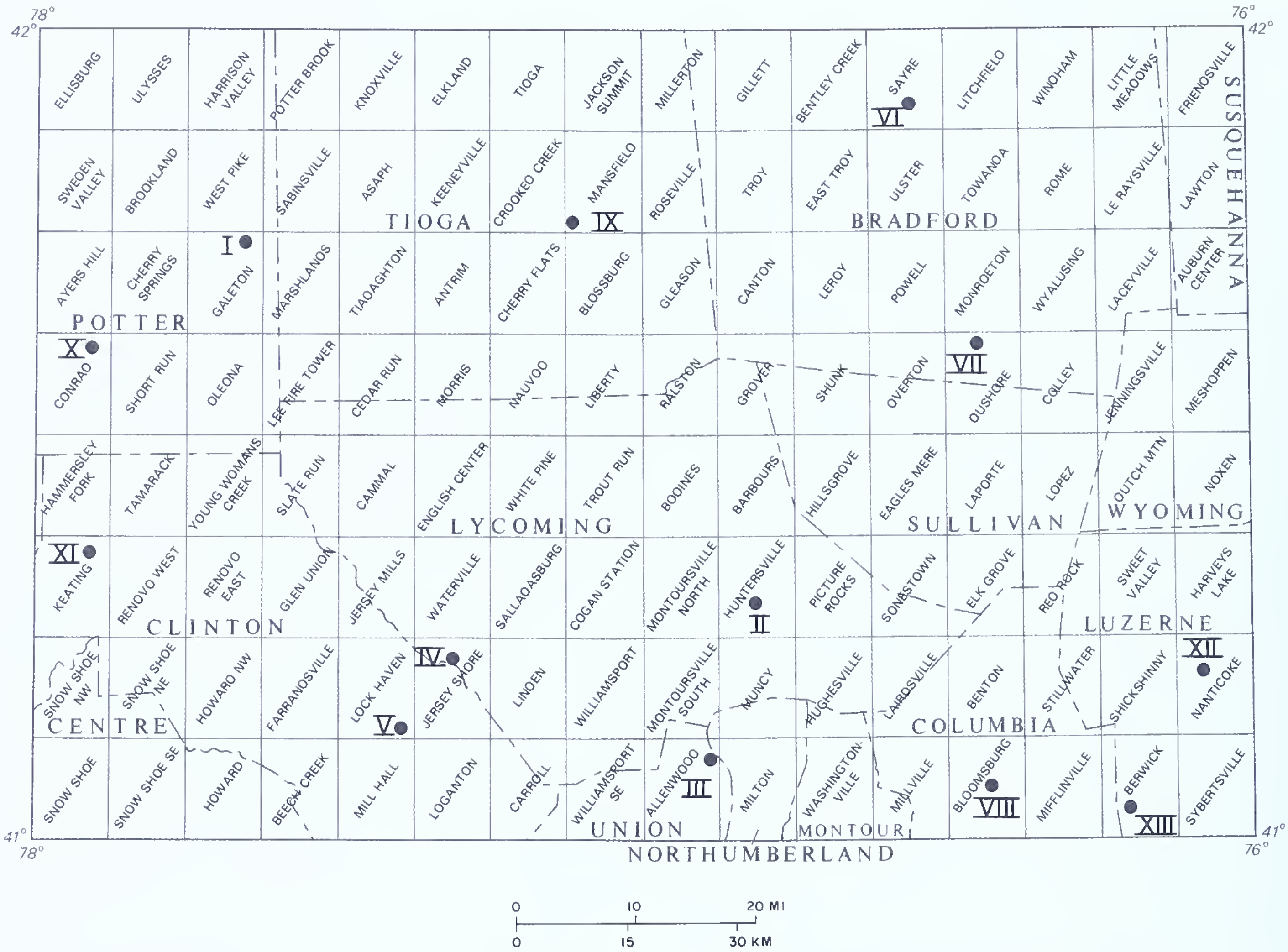

Figure 19. Index map of 7.5-minute quadrangles in the Williamsport 1- by 2-degree area, showing the locations of landslide areas discussed in detail in the text.

has been, and continues to be, an active geologic agent in this area and that it contributes to the development of the landscape of north-central Pennsylvania.

Some portions of the study area are more susceptible to landslide occurrence than others. These areas are delineated on Plate 1, and the criteria used to establish each are explained in the text section "Landslide Susceptibility." Although some factors that have an effect upon landslide susceptibility (Table 4) can be designated on a map, two significant factors cannot be so shown, and may lead to landslides and their resultant deposits in any part of the study area. First, heavy precipitation in intense storms may cause generally stable slopes to fail and will almost certainly cause some unstable ones to fail. The heavy rain associated with tropical storm Agnes in June 1972 triggered many landslides in the eastern part of the map area that had little correspondence to any mapped slope designation. Second, construction activities that involve cut and fill can generate landslides in freshly made cuts or on adjacent natural slopes. For example, simultaneous dam and highway construction in 1978 in Tioga County triggered a major landslide in sensitive, unconsolidated glacial deposits.

Any one, or a combination, of the factors listed in Table 4 will have an influence on the likelihood of occurrence of a landslide and will be discussed in greater detail in the next section ("Factors That Affect Landsliding").

In the Williamsport area, each of the seven landslide types is characteristic of specific terrain types, although not entirely limited to these. Debris avalanches and debris slides are characteristic of steep slopes of the deeply incised stream valleys in the western part of the area. Debris flows are characteristically slow moving, and develop in unconsolidated glacial material in the northern and eastern parts of the area. Rockfalls and rockslides can occur from any cliff or rock face, but are most common and of greatest consequence along constructed rock cuts for highways in the western and southern parts of the area. Slumps are a common form of slope failure along stream banks throughout the area and are also characteristic of cut slopes in unconsolidated glacial

deposits in northern and eastern sections. Slumps combined with debris flows or earthflows are characteristic of areas of thick colluvium or moderately thick glacial deposits on moderately steep valley sides in northern and western parts of the area. Composite landslides are not characteristic of any specific localities, because they are combinations of the other types and have diverse properties.

Detailed Observations of Individual Landslides

The field work in this study included an examination of a number of landslides in some detail. This examination involved measuring major features, preparing a sketch map, sampling the material in some slides, and noting general geologic features of the slide and surrounding area. An attempt was made to select sites that are representative of the various types of landslides and of the different geologic and physiographic divisions of the area. Figure 19 shows the locations of the 13 landslide occurrences discussed below.

I. Galeton Quadrangle

This slide is a progressive slump failure in glacial-lake clay, till, and colluvium. The slump is located on the north side of U.S. Route 6 in Galeton Borough, Potter County. The slide is across the highway from and about 50 feet above Pine Creek. A location map is given in Figure 20.

The top of the slump is slightly below the level of the contact between the Devonian Catskill Formation and the Mississippian and Devonian Huntley Mountain Formation. These sandstones and shales dip very gently to the northwest. Glacial-lake deposits, ground moraine, and local colluvium of Olean (latest Wisconsinan) age overlie the bedrock at the site, which is very close to the Wisconsinan glacial border (Crowl and Sevon, 1980). The mapped soil is Cattaraugus channery silt loam.

Figure 21 is a sketch map and cross section of this slump, which is approximately 300 feet long and about 535 feet wide at the toe, faces south-southwest, and has a slope of between 25 and 30 percent. The elevation at the toe is 1,370 feet; total relief on the slide is approximately 80 feet. It occurs near the base of an 800-foot-high slope above Pine Creek that is wooded, having small (1 to 12 inches in diameter) deciduous trees. Figure 22 is a photograph taken from U.S. Route 6, looking northwest across the slide.

Approximately 10 feet of brown, stiff glacial-lake clay is exposed at the toe, where slide material has been

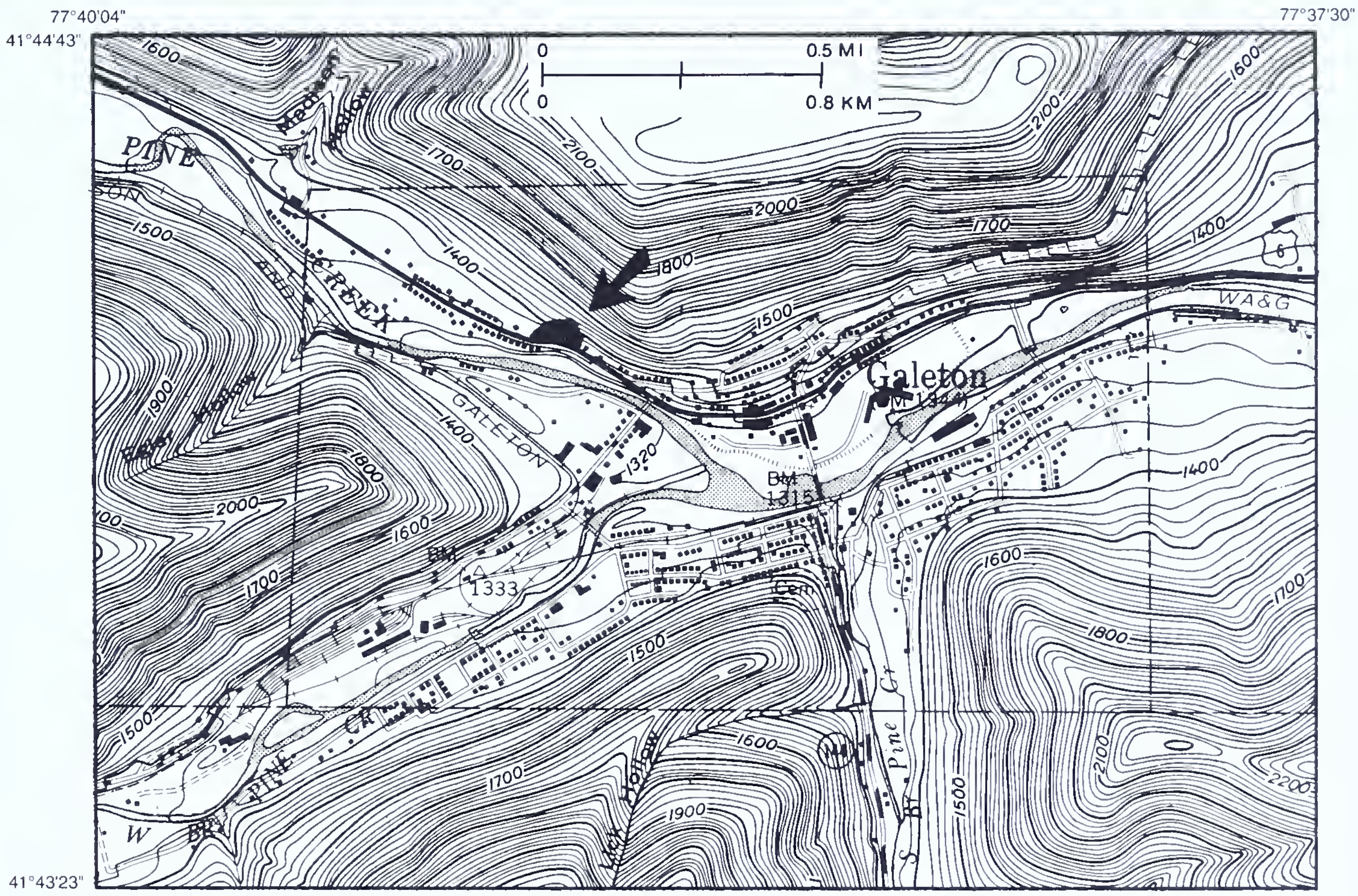

Figure 20. Location of a slump along U.S. Route 6, Galeton.

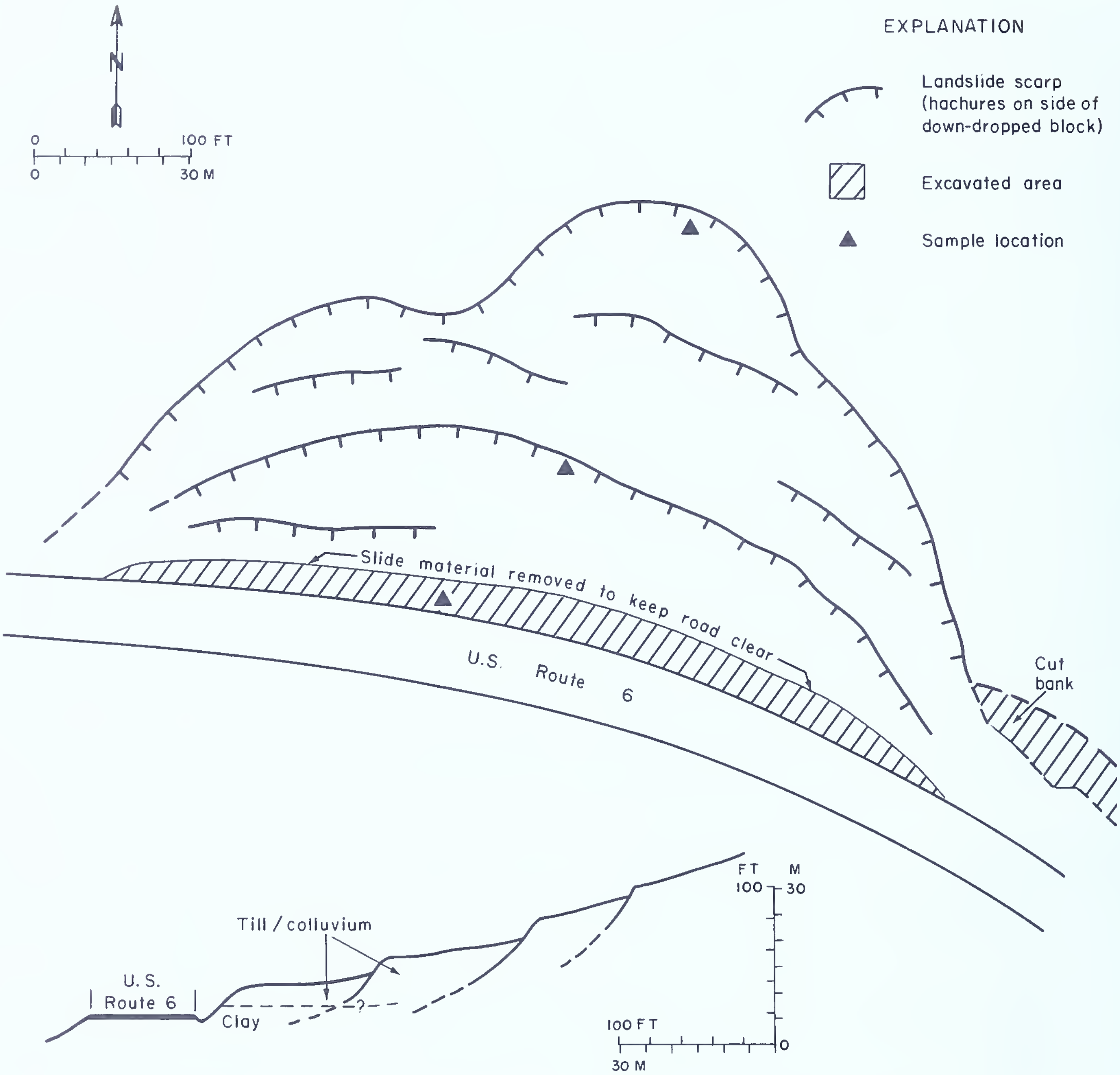

Figure 21. Sketch map and schematic cross section of the Galeton slide.

Figure 22. The toe and lower scarp of the Galeton slide. The light snow cover emphasizes the multiple scarps.

removed to keep the road clear. X-ray diffraction analysis of the clay indicates the presence of smectite. A sample of the clay was analyzed for engineering strength properties, and the results are on file at the Pennsylvania Bureau of Topographic and Geologic Survey in Harrisburg. Above the clay, red-brown till is exposed; the uppermost section of the slide occurs in colluvium or colluviated till. The slide body is a series

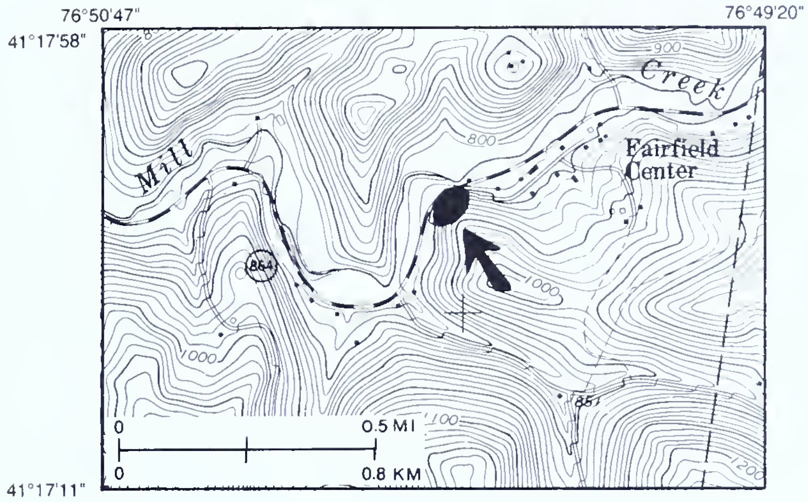

Figure 23. Location of the Huntersville rockslide and debris slide.

of slump blocks, and earthflow has taken place at the toe. The pattern of scarps indicates probable progressive slump failures. Evidence of recent sliding below the highway is lacking.

Except during very dry weather periods, the slide area is wet, the toe is very wet, and water runs in the ditch along the roadside. No ponding of water was observed in the body of the slide.

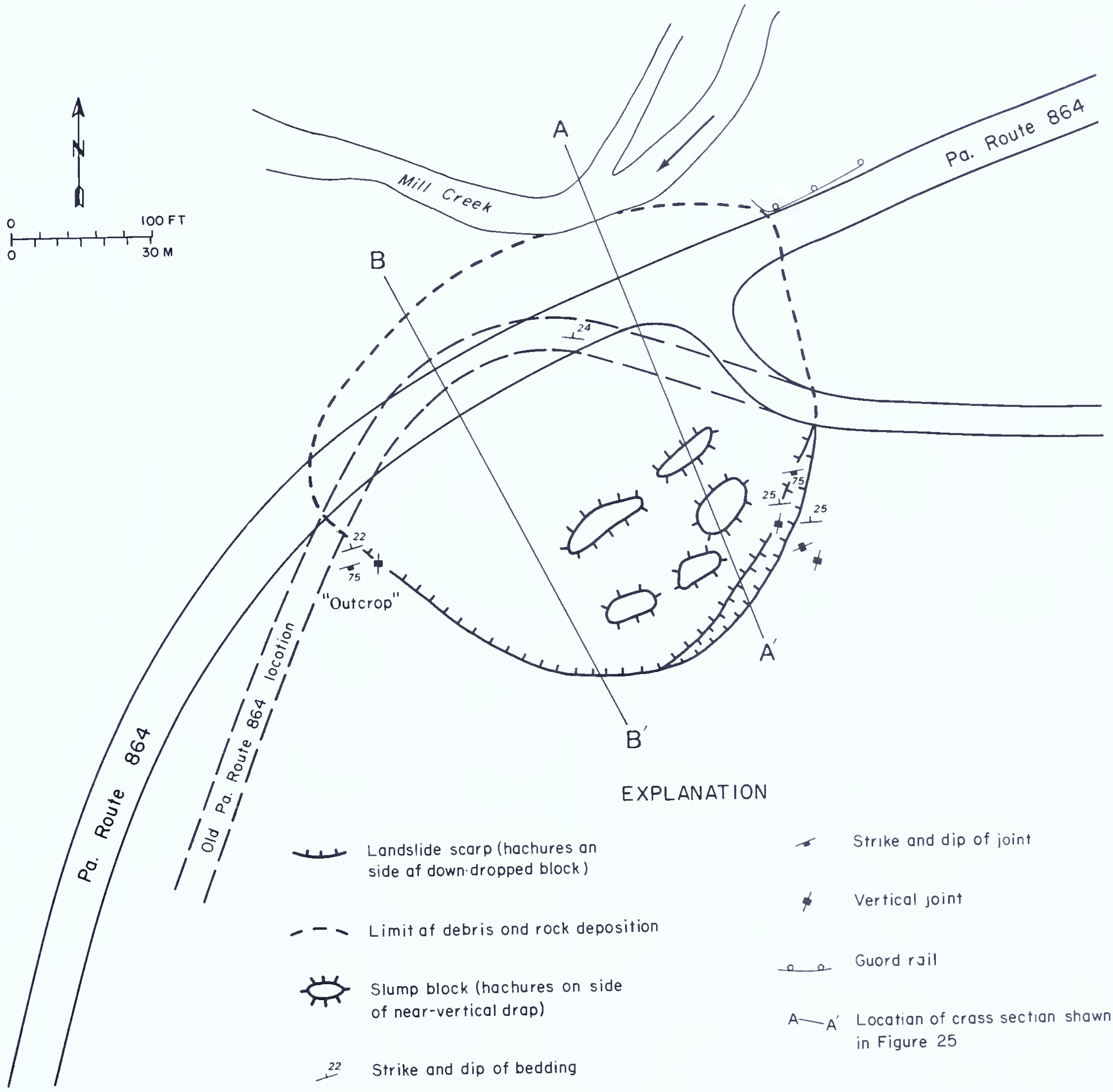

Figure 24. Sketch map of the Huntersville slide.

II. Huntersville Quadrangle

On January 13, 1983, a rapid rockslide and debris slide blocked Pa. Route 864 in Upper Fairfield Township, Lycoming County. Additional sliding occurred on January 15 or 16 and January 23, after more rain and some highway cleanup activity. The site is approximately one half mile west of the village of Fairfield Center (Figure 23), and is at the base of a northwest-facing, convex slope above Mill Creek.

The bedrock involved is sandstone, siltstone, and shale of the Catskill Formation, approximately 550 feet stratigraphically above the base of the formation. Attitudes of N85°E, 25°NW and N73°E, 22°NW were measured at the head and toe of the slide (Figure 24). Approximately 2 feet of yellowish-brown channery silt loam overlying the rock is exposed in the head scarp. No evidence of any surface water or groundwater concentration was observed. One inch of rain was reported locally on January 10 and 11. The adjacent wooded slopes are steep, ranging from 28 to 35 degrees (53 to 70 percent slope). The bedrock at the toe of the slide area had been cut when the road was relocated in 1980 (Figures 24 and 25).

The length of the slide from head scarp to toe is 250 feet, and the width is 362 feet along the road. The vertical relief between the head scarp and the road is approximately 100 feet. The head scarp is up to 10 feet high and exposes rock and thin soil. The upper portion of the slide mass is composed primarily of large intact blocks, which are commonly covered with soil and trees and other vegetation (Figures 14 and 26). The orientation of trees indicates that some blocks have been rotated into the slope, as in a slump, while others have rotated out, as in a topple. Material is progressively more broken lower on the slope, but large, intact blocks (at least one up to 40 feet long) were observed (Figure 27). The debris consists of roughly rectangular fragments of olive to gray to reddish-brown siltstone, olive shale, red to brown very fine sandstone, and buff to tan claystone. Block size ranges from about 1 inch to 40 feet in maximum dimension, but most are less than 3 feet. The fragments are platy, having length:width:thickness ratios ranging from 10:7:1 to 4:4:1.

By late January 1983, enough material had been removed to clear the road. The areal extent of the toe could be mapped, although the original toe conditions are unknown.

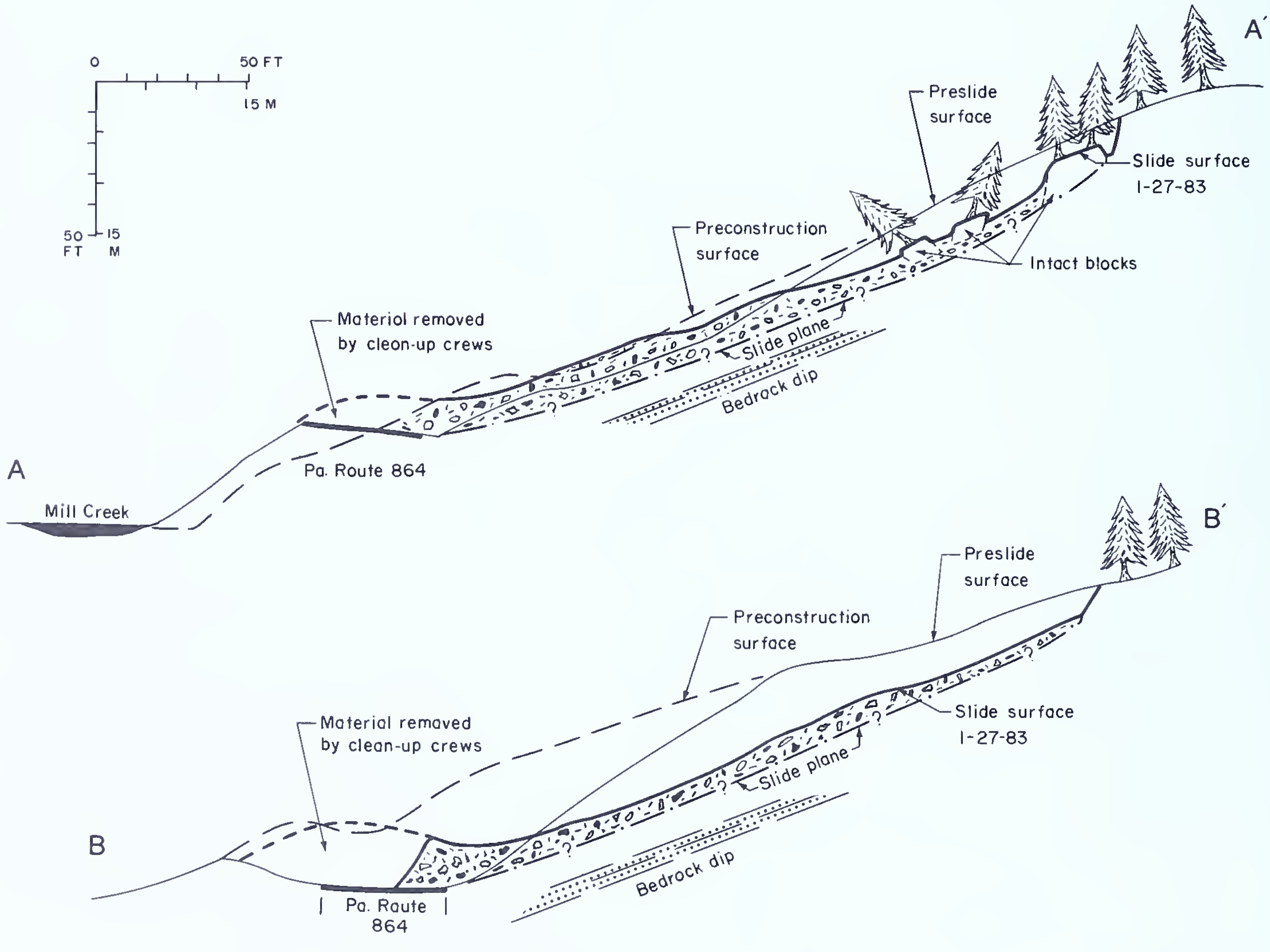

Figure 25. Cross sections of the Huntersville slide. Locations of cross sections are shown in Figure 24.

Figure 26. Large tree-covered blocks on the upper portion of the Huntersville slide. A bulldozer to the right gives approximate scale.

No free water or wet zones within the slide were observed. Failure apparently occurred along bedding planes and joint openings in response to the loss of support from the excavated toe material. The Northeast Seismic Network office at The Pennsylvania State University (oral communication, 1983) reported no seismic events at the time that could have triggered the slide.

Although the slide caused no direct injury to people or private property, Pa. Route 864 was closed for 12 days. The *Williamsport Sun-Gazette* (January 19, 1983) mentioned a highway department cost estimate of $20,000 for removal of 10,000 cubic yards of material. The estimate predated the second and third slide events of January 15 or 16 and January 23, which added approximately 5,000 cubic yards of additional rock and debris. As of January 24, 1983, all loose material had been removed from the roadway, and a 5-foot-wide shoulder had been cut along the pavement to collect additional falling debris. Final stabilization efforts may involve excavation of the slide area down to stable bedrock.

III. Allenwood Quadrangle

Three small rockslides occur along U.S. Route 15 in Gregg Township, Union County, above the West Branch Susquehanna River, between 1,000 and 3,000 feet south of the mouth of White Deer Hole Creek. They lie on a steep rock face where the highway grade is cut into the high riverbank. The northernmost failure is a wedge-failure-type rockslide, the adjacent one is a planar rockslide, and the southernmost one is a rock topple (Figures 28 and 29). All three slides are related to an extensive highway-widening roadcut completed in 1957 and have forced closings of the highway at times since then.

The slides are in shale of the upper part of the Silurian Rose Hill Formation of the Clinton Group along the north limb of the anticline that forms White Deer Mountain. Inners and Wilshusen (1986) measured the attitudes of natural rock discontinuities in the roadcut, and Figures 29, 30, and 31 were prepared

Figure 27. Photograph of the central portion of the Huntersville slide. The large, partially debris-covered blocks (on either side of the person indicated by an arrow) have moved. Note the variation in size of rock fragments.

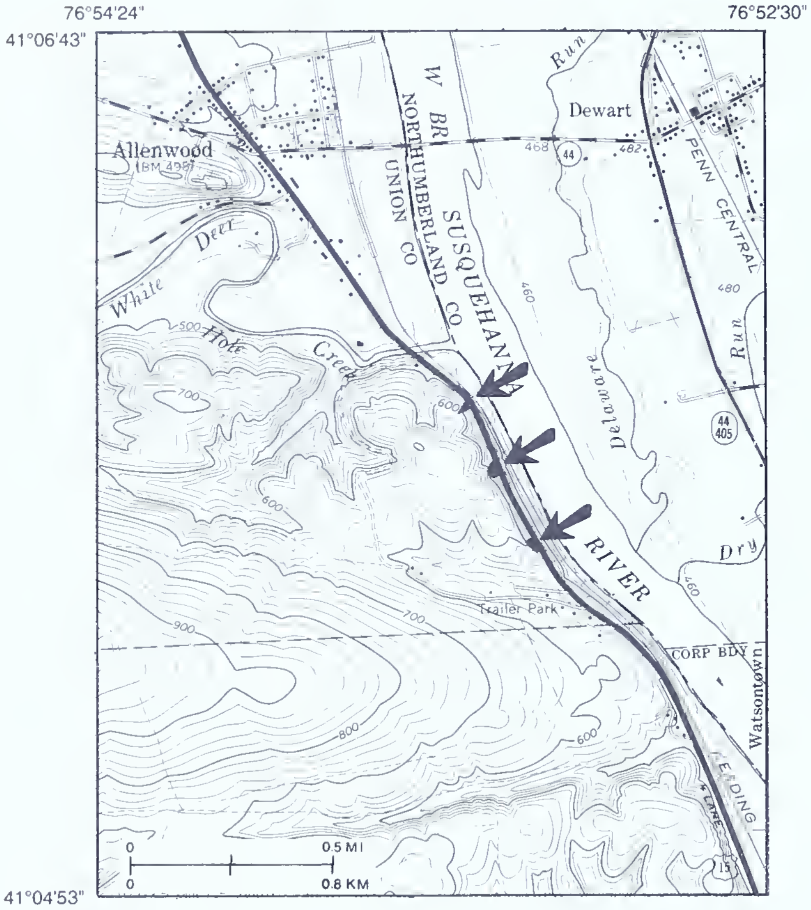

Figure 28. Location of rockslides near Allenwood.

from their data. The dimensions of the slides shown in Figure 29 reflect the conditions that existed at the time of their study.

The wedge failure (shown in Figure 13) at the north end of the cut is about 150 feet long and 25 feet wide at the road edge. The wedge axis plunges 42 degrees toward N46°E. The recurrent rockslide (Figure 32) is approximately 75 feet long and 120 feet wide, and has a head scarp about 15 feet high. The slope of the debris surface became 35 degrees following removal of the loose material blocking the highway. This site has been a problem since shortly after the road opening. In 1970, the southbound lanes were closed after large cracks were observed in the shale. PennDOT removed much of the loose material by blasting, creating the general configuration of the present slope. Repeated rockslides forced closing of the highway in January 1974 and May 1983. Although the slide area is now partially stabilized, the near-vertical head scarp in fractured rock is a potential site for further sliding.

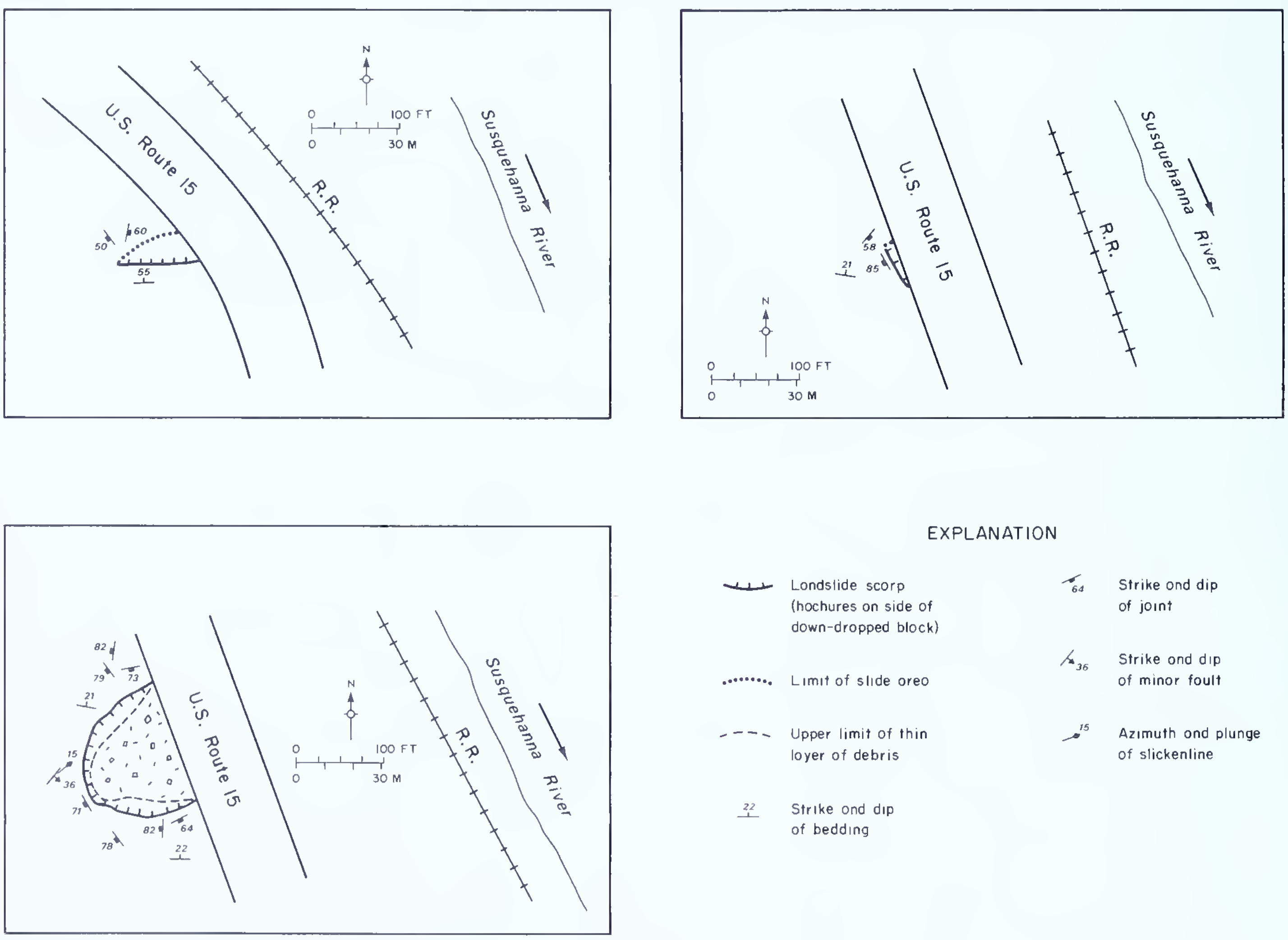

Figure 29. Sketch maps of individual rockslides near Allenwood (modified from unpublished data). Top left, wedge failure; top right, rock topple; bottom left, recurrent rockslide.

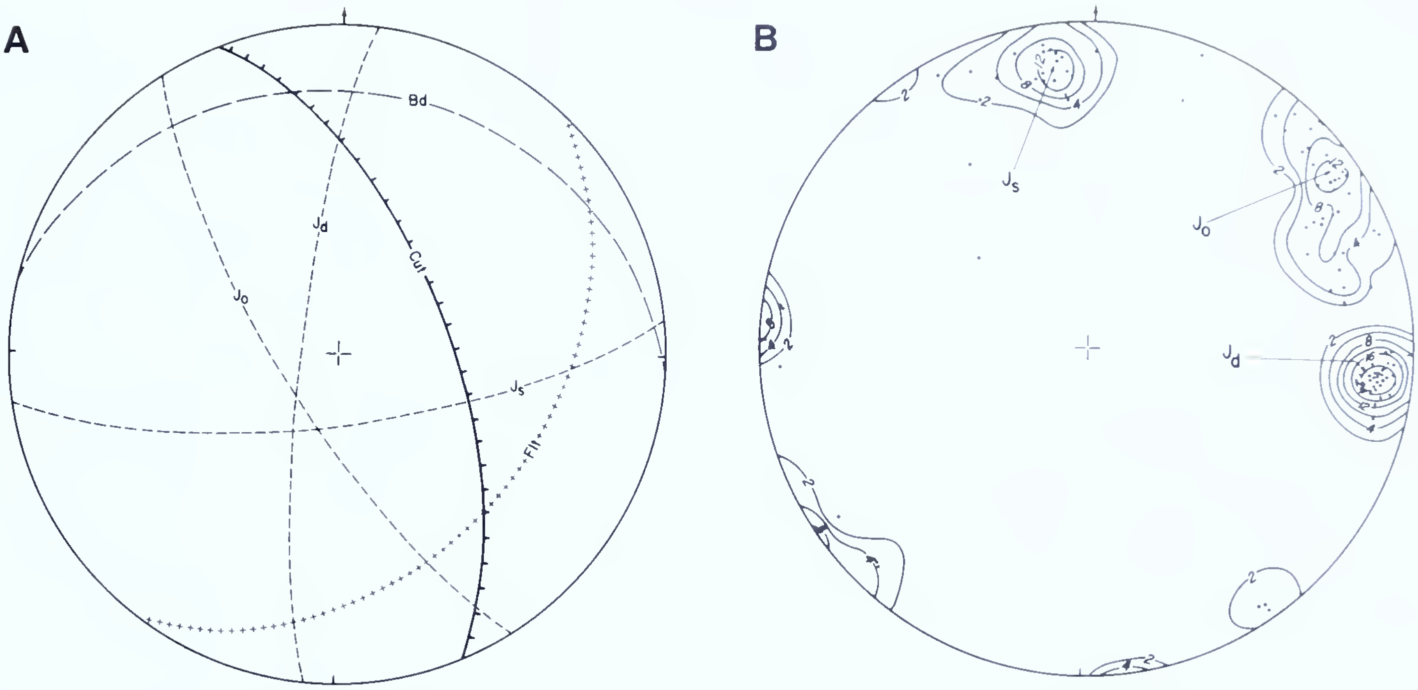

Figure 30. Stereograms (equal-area lower hemisphere projections). A. Discontinuity planes in shale at the site of a large recurrent rockslide near Allenwood (from Inners, 1997, p. 94). Bd, bedding (N82°W, 21 degrees NE); J_s, strike joints (N82°E, 73 degrees SE); J_d, dip joints (N6°E, 81 degrees NW); J_o, oblique joints (N33°W, 76 degrees SW); Flt, fault (N42°E, 36 degrees SE). The cut face shown in the diagram (N22°W at 1/2:1, or 63 degrees slope to the northeast) is the slope angle prior to attempted rehabilitation in the fall of 1970. B. Contour diagram of the poles of 100 joints at the Allenwood cut (from unpublished data). Contours are at 2, 4, 8, 12, 16, and 24 percent per 1 percent area. J_s, strike joints; J_d, dip joints; J_o, oblique joints.

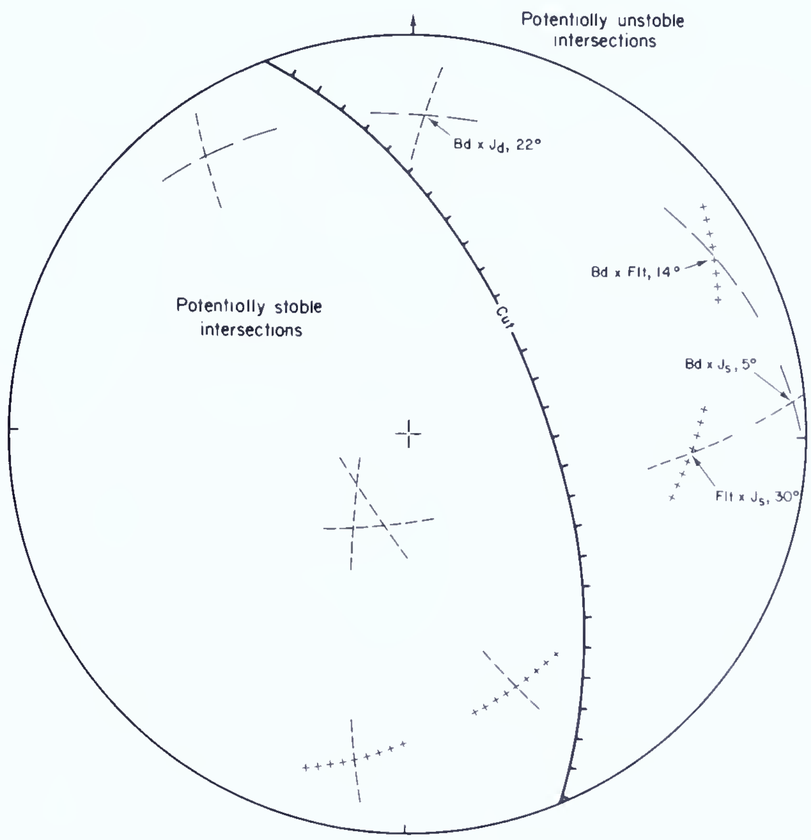

Figure 31. Stereogram (equal-area lower hemisphere projection) showing the relative stability of discontinuity intersections at the site of a large recurrent rockslide near Allenwood (from unpublished data).

Figure 32. The large recurrent rockslide near Allenwood.

IV. Jersey Shore Quadrangle

During an intense local rainstorm on the night of May 14, 1978, a debris avalanche moved down the steep slope where Pine Creek cuts through the Allegheny Front near Torbert, in Watson Township, Lycoming County (Figure 33). The toe of the debris flowed around a house, badly damaging the porch, which was later removed. The slide is classified as a debris avalanche-flow in old landslide deposits and/or colluvium. No apparent bedrock failure took place.

Interbedded sandstones, siltstones, and shales of the Devonian Catskill Formation and Mississippian and Devonian Huntley Mountain Formation underlie the slide area. The approximate elevation of the Catskill-Huntley Mountain contact is 900 feet, which is 280 feet above the toe and 250 feet below the head of the slide. The lower end of the surface of rupture is approximately at the contact (Figure 34).

The geologic structure is fairly complex. The slide is located very close to the axis of an extremely asymmetric (faulted?) syncline. Colton (1967) and the *Geologic Map of Pennsylvania* (Berg and others, 1980) showed a north-northwest-trending fault slightly above the head of the recent slide. Colton showed this fault as questionable. Field and aerial-photograph examination suggests that the displacement along this "fault" may be due instead to a very large (more than 1,000 feet wide) bedrock slump. Bedding attitude and field appearance are consistent with this idea. No surface expression of the fault where it is mapped crossing Pa. Route 44 north of the slide area was found during field reconnaissance.

The area below the rock slump or fault is clearly discernable on 1963 aerial photographs as an old landslide area and is indicated on Figure 33. The surrounding slopes appear to have a thin cover of boulder or channery colluvium. The recent slide is entirely within the older slide area.

No external sources of surface water were observed. The uppermost appearance of water is just above the toe of the surface of rupture, which is also the approximate location of the Catskill-Huntley Mountain contact. Water flows down to the toe where drainage diversion channels have been cut to lead water out

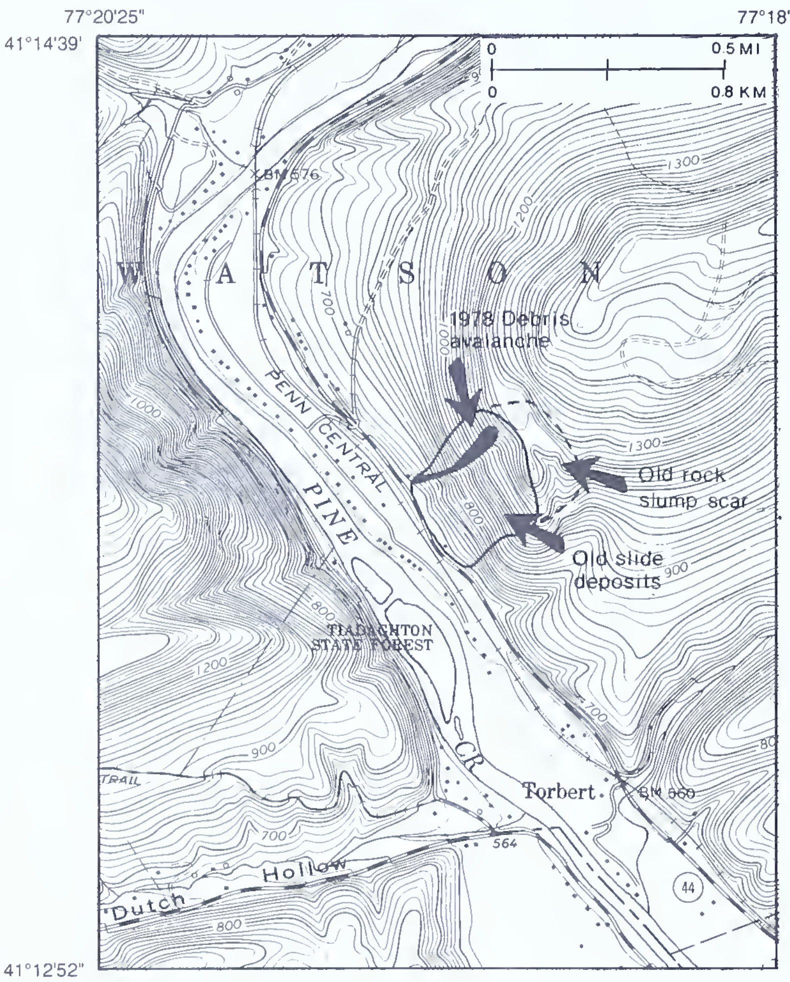

Figure 33. Location of a complex debris avalanche-flow at Torbert on the Jersey Shore quadrangle.

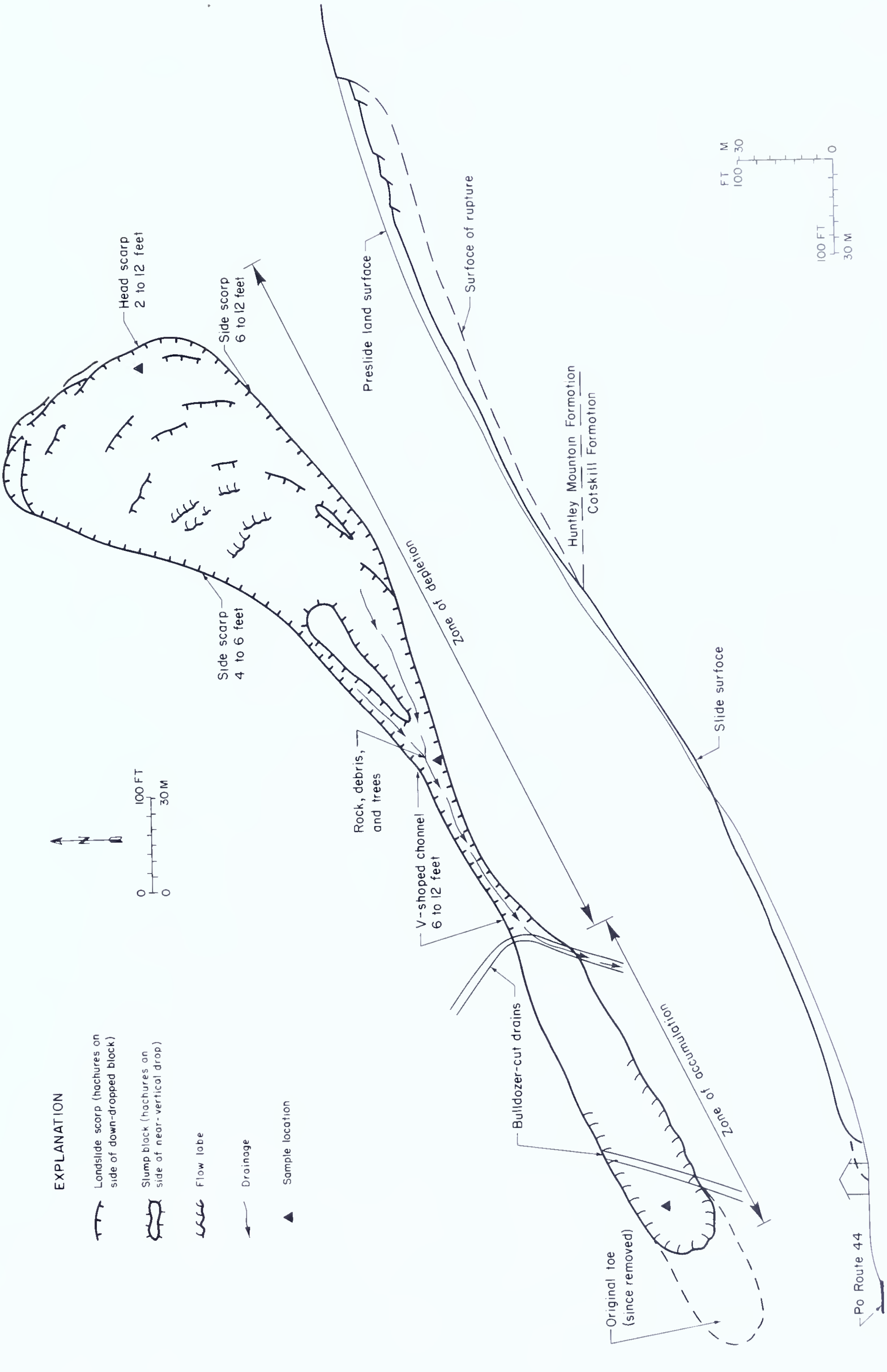

Figure 34. Sketch map and schematic cross sections of the Torbert slide.

of the toe deposits. The upper part of the slide area is spongy and somewhat wet, but no ponding was observed.

The maximum length of the slide, corrected for slope, is 1,125 feet. The greatest width is 262 feet at the head. The slide narrows to 20 feet at the central "chute" area, and the deposit at the toe is 65 feet wide. The elevation at the head is 1,150 feet, and at the toe it is 620 feet, for a maximum relief of 530 feet. The southwest-facing slope has an average steepness of 25 degrees, or 46 percent.

The upper section of the slide is a slump-earthflow having multiple scarps and benches. Below the crown, this section has multiple isolated slump blocks and minor earthflow lobes. The scarp height ranges up to 12 feet. The material exposed in the scarps is stony colluvium having platy, subangular sandstone fragments (4 inches to 2 feet in maximum dimension) in a red-brown clay-silt matrix. Water was observed flowing from the lower flow lobes and slump blocks. The slope of this portion of the slide ranges from 18 to 30 degrees.

The central section of the slide is a 20- to 40-foot-wide, 6- to 12-foot-deep, V-shaped, scoured channel having no vegetation (Figures 35 and 36), and a very thin deposit of boulders and smaller rocks in the bottom of the channel. Material has moved through this zone with little or no deposition. Trees on the edge of the channel are abraded and scarred to a height of about 4 feet above the original land surface, presumably by moving debris. Possible exposures of bedrock can be seen in the channel, but they may be large, horizontally oriented rock fragments. At the time of the authors' inspection, there was a continuous flow of water in the channel, which has a slope of about 32 degrees.

The toe of the slide consists of the debris-flow deposit. The extreme lower end of the deposit has been removed to allow repairs and access to the house. The deposit is composed of fallen trees and other debris thoroughly mixed into the stony silt and clay slide material. Maximum thickness of the deposit is 20 to 30 feet. The slope angle decreases downslope through this section from 24 degrees to 15 degrees.

Figure 35. Photograph looking up through the central "chute" portion of the Torbert slide at the lower part of accumulated slumped material. Sandstone layers may be bedrock or large debris.

Figure 36. Photograph looking down through the central "chute" portion of the Torbert slide. The person in the center of the photograph provides scale.

V. *Lock Haven Quadrangle*

The Lock Haven landslide is a complex planar slide-earthflow in colluvium (and glacial deposits?) along the south side of U.S. Route 220 (Lock Haven bypass) in Wayne Township, Clinton County. The site is on the north side of Bald Eagle Mountain, just above the confluence of Bald Eagle Creek and the West Branch Susquehanna River. The failure occurred during highway construction, following cutting of the toe of the slope.

Shales and limestones of the Mifflintown, Bloomsburg, and Wills Creek Formations (Middle and Upper Silurian in age) comprise the bedrock at the site. An attitude of N65°E, 55°NW was measured in an exposure near the toe of the slide. The surficial deposits overlying the bedrock have been described as a complex of Illinoian glacial deposits and colluvium based on the presence of a reddish soil profile in colluvium above till-like boulder clay. This soil profile is overlain by younger colluvium. A lobate deposit from an ancient (periglacial?) landslide can be seen on the topographic map (Figure 37) of the site.

The adjacent wooded slopes are covered with colluvium derived from the higher slopes of Bald Eagle Mountain. A similar, but smaller, failure occurred approximately 1 mile east of this site. A boulder field (of Tuscarora sandstone) believed to be of periglacial origin lies on the upper slope of Bald Eagle Mountain about 300 feet above the base of the slide. This field, which can be seen in Figure 5, is possibly related to the ancient landslide deposit that occurs directly below it (Figure 37).

The recent slide is approximately 460 feet long and 1,350 feet wide along a 20-degree, north-northwest-facing slope (Figure 38). Maximum relief on the slide is about 150 feet. The pre-slide surface (from the topographic map) was planar to slightly convex. The undisturbed 12-degree slope immediately above the head scarp shows some minor surface drainage.

The maximum relief on the main head scarp is approximately 8 feet, decreasing to 3 to 4 feet at the sides. The scarp is fresh and apparently active. An upper block, about 70 feet wide, has dropped (as a graben) about 4 to 6 feet, which indicates planar rather than rotational failure. The material exposed in the scarp is yellow-brown stony colluvium and is not particularly clay rich at the sample location. At the east end of the slide (Figure 39) are multiple minor scarps having vertical displacements of 2 to 6 feet. At the west end, excavation and installation of drainage have altered the surface detail. A boulder-lined drainage ditch probably follows the trend of an earlier scarp. Head-scarp relief decreases to the east, and the scarp dies out in the woods. A lower scarp curves around and defines the east flank of the slide.

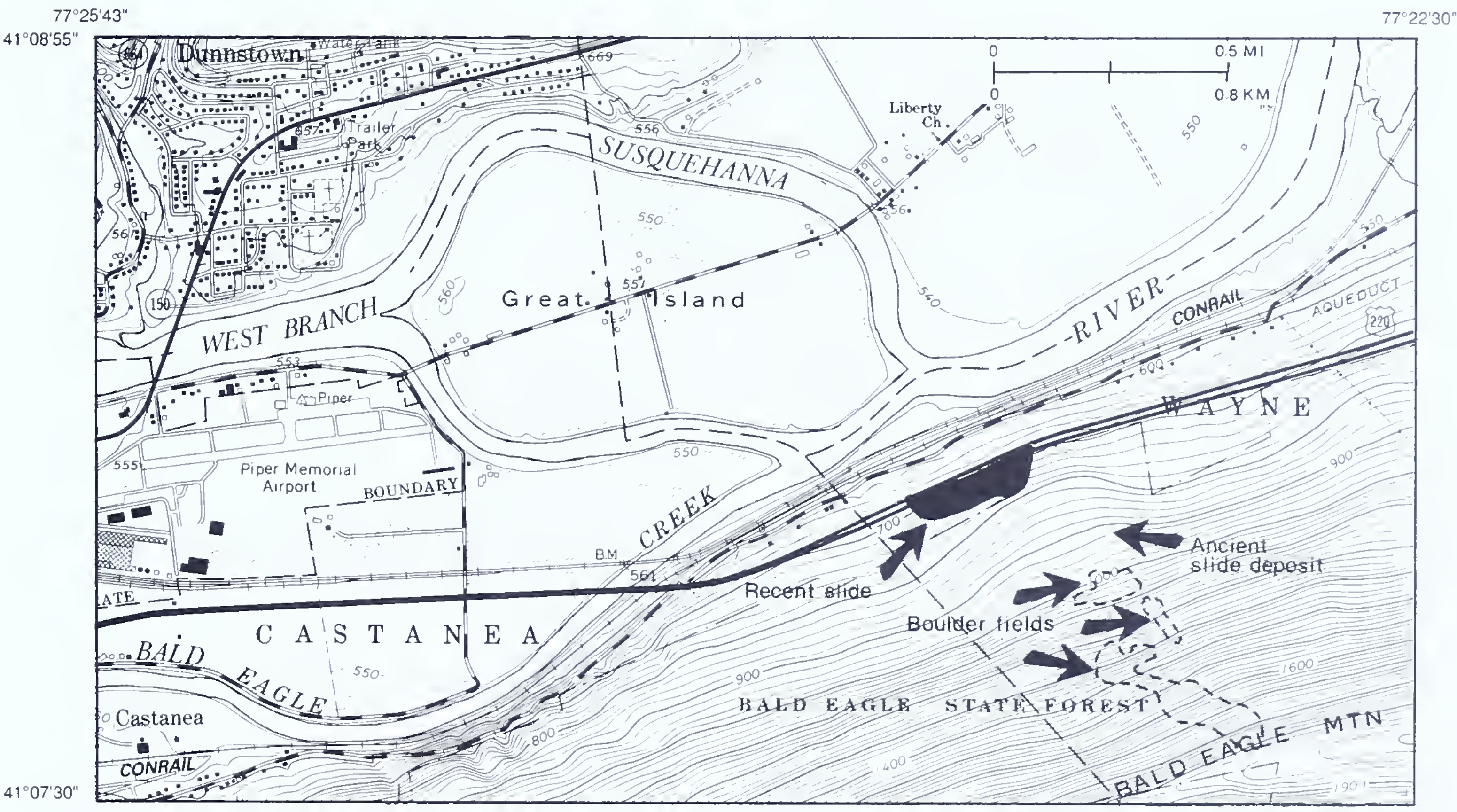

Figure 37. Location of the Lock Haven landslide. Note the boulder fields and topographic bulge of an old landslide deposit above the recent slide area.

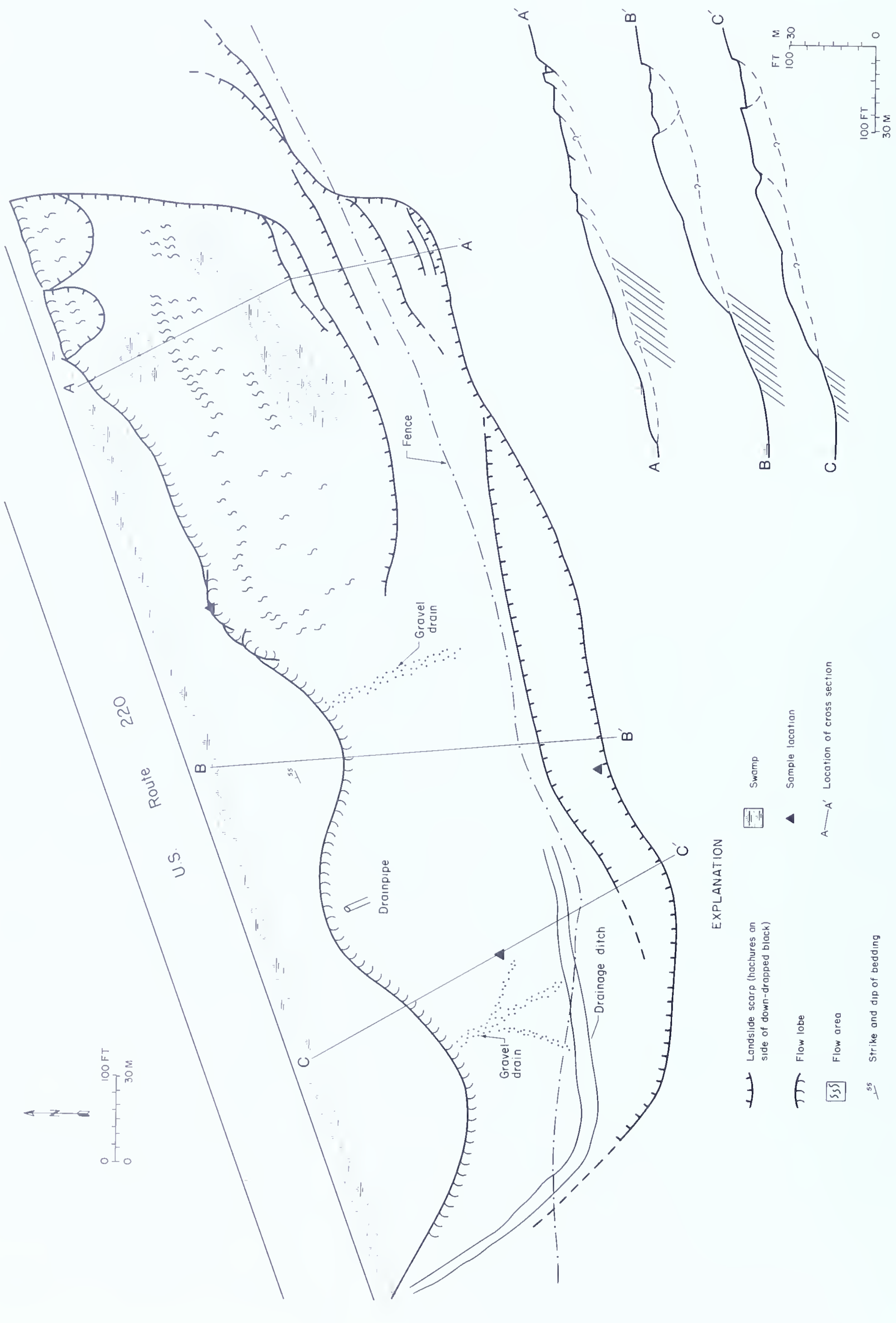

Figure 38. Sketch map and cross sections of the Lock Haven slide.

Figure 39. The eastern part of the Lock Haven slide from near the center of the toe. Note the secondary scarps, flow lobes, and cattail growth on top of the slump block and at the toes of flow lobes. The main head scarp is out of view in the woods.

The lower portion of the slope was cut to allow highway construction, and a large volume of material has been removed since the initial slide failure. Most of the area within 100 to 150 feet of the road has been cut back to bedrock and is thickly covered with grass and/or crown vetch. The toe of the slide has flowed over the cut bedrock surface (Figure 40). The west end of the slide area has had an extensive drainage system installed. The eastern end is poorly drained, having large swampy areas that support cattail growth, and is actively moving closer to the road edge. The surface is hummocky, wet, and stony and has active small earthflow lobes (Figure 41).

VI. Sayre Quadrangle

This complex slump-earthflow in glacial-lake clay and till and/or colluvium is on the north bank of Buck Creek in Ulster Township, Bradford County (Figure 42). The site is 1.2 miles west of Milan on S.R. (Pennsylvania State Route) 4014, approximately 1.5 miles above the confluence of Buck Creek with the Susquehanna River. The slide is active, the west end being at least several years old. Recent damage to the road has occurred near the center of the head scarp (Figures 43, 44, and 45). Movement of this slide has been monitored with inclinometers by PennDOT. Repair efforts have included regrading and emplacement of fill at the top of the slide. Stream erosion at the toe is assumed to be the primary causative factor for instability.

The Upper Devonian Lock Haven Formation underlies the site and crops out along the road 0.2 mile west of the slide, where bedrock attitude is N88°W, 5°NE. Gray silty clay, interbedded with light-brown silt and having scattered dropstones (interpreted as varved glacial-lake deposits), is exposed in the landslide scarps. Reworked, very plastic, gray clay, overlain by a cobble and pebble pavement, is exposed at the toe. The clay extends to at least 25 feet above stream level and is overlain by till and/or colluvium. The mapped soils are Chenango, which is characteristic of outwash terraces in stream valleys, and Volusia, which typically forms on glacial clays and tills (Rayburn and Braker, 1981).

Figure 40. An active minor earthflow in the eastern part of the Lock Haven slide. The slope below the flow was excavated to bedrock during highway construction.

Figure 41. Close-up photograph of the toe of an active earthflow lobe in the Lock Haven slide. The pick is approximately 20 inches long.

An active stream is flowing at the toe of the slide. Several wet to extremely wet areas were observed in the lower slide mass, but no surface drainage into the slide area was seen. A storm drain in the road across from the slide is a possible source of water to the slide.

Another small slide lies immediately adjacent downstream, but no other slide activity was observed above the road or elsewhere in the immediate vicinity of this slide. Bedrock is exposed upstream of the slide in the stream bed and downstream along the northeast bank. The entire section of stream bank underlain by this local glacial-lake deposit appears to be affected by the slide.

The slide is approximately 190 feet long and 1,100 feet wide and has about 60 feet of relief. The hillside faces to the south-southwest and slopes at about 20 degrees. The head scarp is largely obscured by the addition of fill and by regrading to maintain the road and shoulder. At the west end of the slide, the active scarp is up to 15 feet high near its intersection with the road (Figure 43). The relief and apparent freshness of the scarp decrease rapidly to the west, and the scarp trace is lost in a grassy field. East of the section along the road, about 25 feet of interbedded gray silty clay and light-brown silt is exposed in the scarp. The clay is also exposed farther downstream in the smaller, immediately adjacent slide.

The main body of the slide has been altered considerably by the construction efforts to maintain the

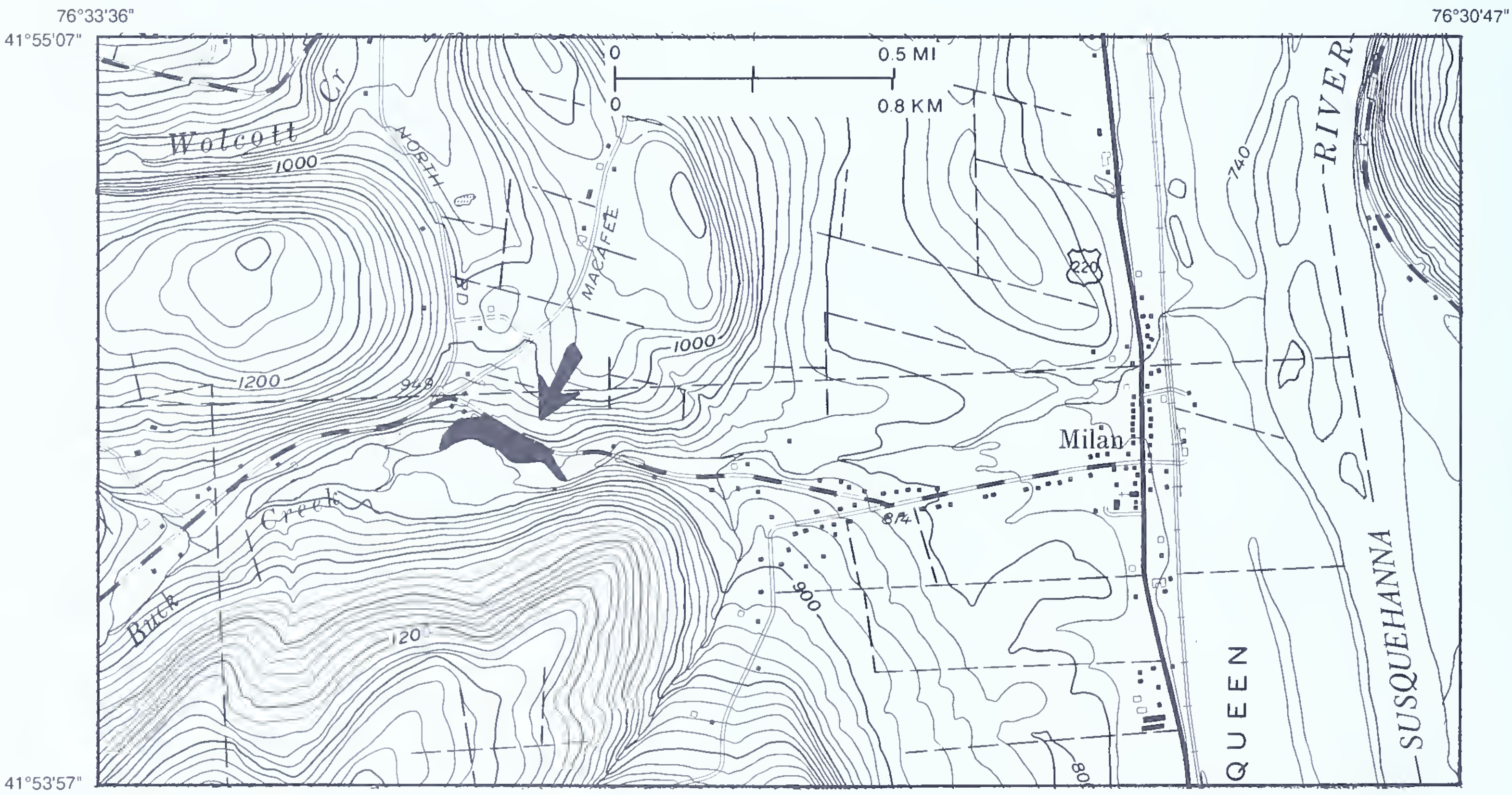

Figure 42. Location of a recent slump near Sayre.

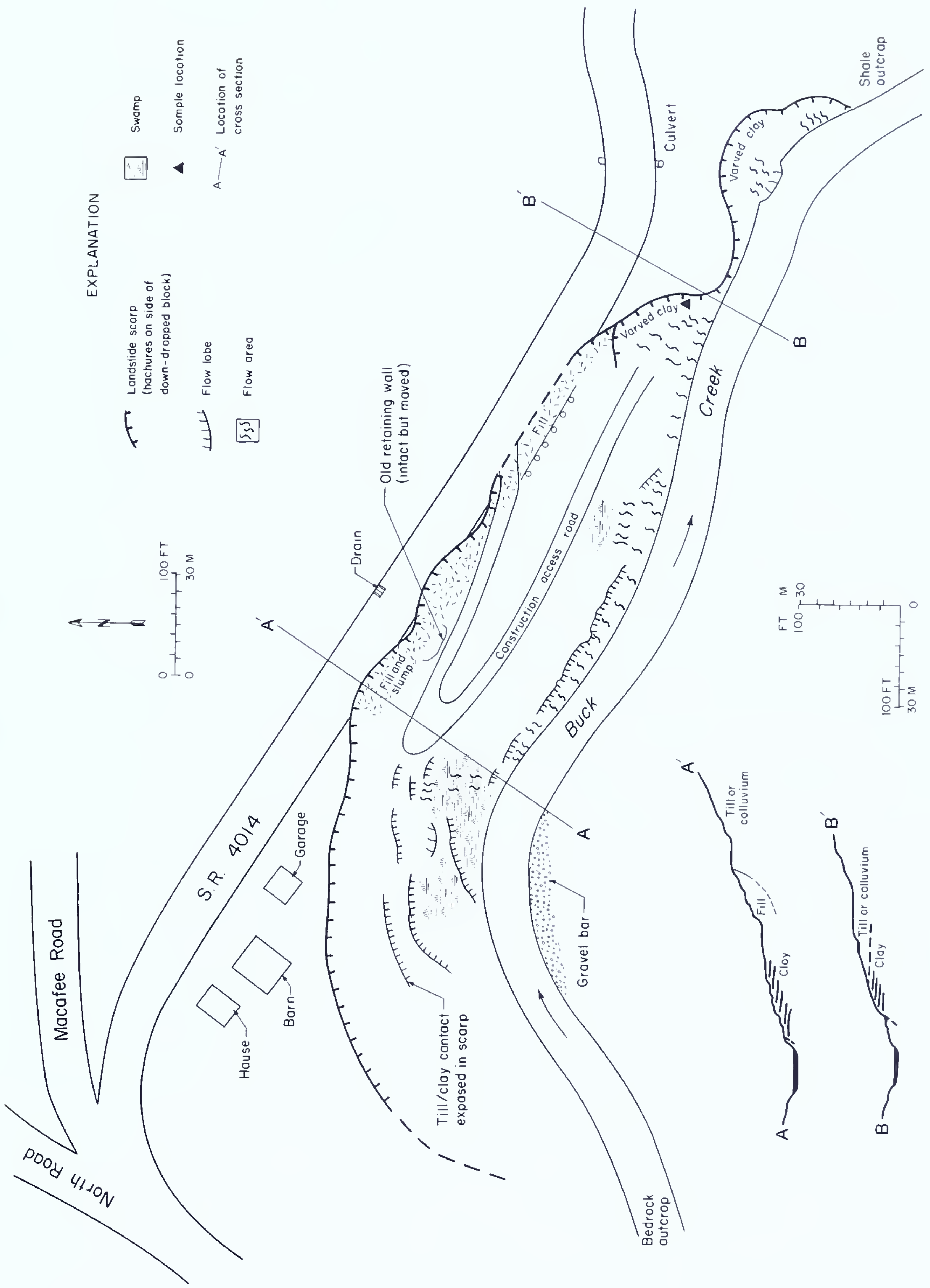

Figure 43. Sketch map and cross sections of the Sayre slump.

Figure 44. Photograph showing the head scarp of the Sayre slump largely obscured by fill and regrading in an attempt to maintain the road. The head scarp is in the roadway beyond the guardrail (marked by a dashed line).

road. Addition of fill is the most obvious change, but there is also evidence of test borings and installation of instrumentation. At the west end of the main body of the slide, the contact between lake clays and the overlying till/colluvium is exposed in a minor scarp. The attitude of the varved bedding here indicates that slump blocks have been tipped back into the hillside from the original horizontal bedding. This presumably occurred in an earlier, larger slump than the present one.

Below the construction access road is an extremely wet, heavily vegetated area. The toe of the slide is very wet all along the stream where earthflow lobes encroach on the stream. These earthflow lobes are primarily clay and have a surface pavement of cobbles and pebbles, presumably derived from overlying till and/or colluvium. Where the clay is exposed in minor scarps near the toe, it has been reworked by slide activity so that the bedding is destroyed and the clay appears as uniform or mottled with no discernable structure.

One sample of varved clay was taken from the exposure at the east end of the scarp. X-ray diffraction analysis showed the presence of major quartz and minor chlorite, mica, and plagioclase. Smectite was not found.

VII. Dushore Quadrangle

A complex slump-earthflow in glaciofluvial material lies on the outside bend of the west bank of the South Branch Towanda Creek, near Stevenson, Albany Township, Bradford County (Figures 46 and 47). The slide was presumably triggered by stream erosion on the outside of the bend. The most recent failure at the head scarp occurred at most a few days before the field visit, since tire tracks in a driveway had

Figure 45. Photograph of the central part of the Sayre slump from across the stream. Damaged guardrail at left is at the site of Figure 44.

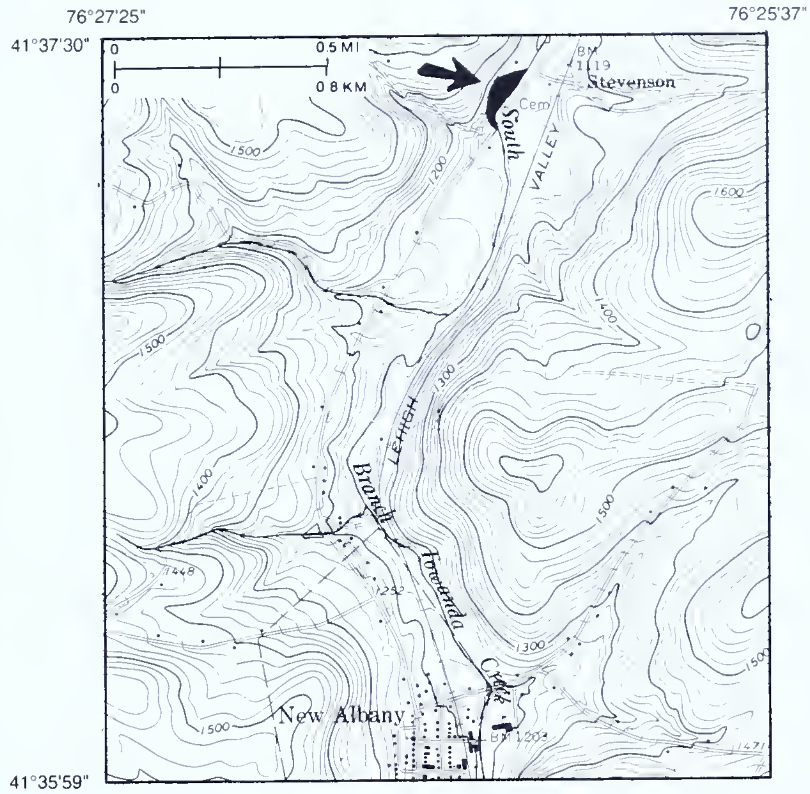

Figure 46. Location of a stream-bank slump-earthflow near New Albany on the Dushore quadrangle.

been broken by slumping. The slide has been active long enough for riprap to have been placed along the stream bank in an effort to reduce stream erosion of the toe of the slide.

The underlying Catskill Formation is not exposed in the immediate vicinity of the slide. The surficial deposits consist of glaciofluvial or glaciolacustrine silt and sand having cobbly and bouldery lenses and layers. Older landslide deposits, indicated by hummocky topography, are present on the adjacent slope to the north. The adjacent surfaces upslope and to the south are covered by colluvium. This site is slightly south of a site where Denny and Lyford (1963) described colluvium overlying lake deposits that in turn overlie till (Figure 48).

Several groundwater seeps were noted within the slide area, and the driveway at the top of the slide may channel surface drainage into the slide area. The slopes adjacent to the slide are steep (35 degrees) and wooded.

The slide is approximately 170 feet long and 525 feet wide at the toe, and has a total relief of about 80 feet. The south-southeast-facing slope has an average steepness of about 35 degrees. The very fresh head scarp is very steep to overhanging. The scarp has cut back across the driveway and fresh tire tracks were still visible on the newly slumped block. The material exposed in the scarp is reddish-brown, stratified silt and sand. Some boulders and cobbles are present (in lenses and layers) in a matrix of sand and silt. The finer grained material is fairly cohesive—large rectangular blocks of bedded silt were observed in the loose material at the toe. The material at the toe appeared to be remarkably free of clay. Some clay may be mixed in with coarser material, but the finest sediment observed was silt sized.

The main body of the slide consists of loose blocks of cohesive silt and sand interspersed with earthflow deposits of unconsolidated sediment. Continual removal of material by the stream at the toe has prevented the buildup of any extensive landslide deposits. In the upper part of the slide, several large intact blocks having tilted trees indicate backward rotation along the failure surface. At other places along the head scarp, trees have tilted forward over the scarp edge (Figure 49). The surface of the main slide mass is either grassy or bare, having only a few small shrubs on the lower parts of the slope. To the northeast of the active slide area is an area of wooded hummocky ground typical of older landslide areas. Several cracks and incipient scarps extend into this area from the active slide.

The slide has completely removed a section of driveway, cutting off access to a house, and is apparently causing continual maintenance problems along the stream.

VIII. Bloomsburg Quadrangle

An active recurrent debris slide occurs on a cut slope along the east side of Pa. Route 487 in Orange Township, Columbia County (Figure 50). The site is on an outside bend of a side channel of Fishing Creek, approximately 1 mile north of Light Street. The material involved in the slide is Glen Brook ice-contact stratified drift (Inners, 1981) or possibly till (Duane Braun, Bloomsburg University, oral communication, 1985) overlying the Trimmers Rock Formation. This deposit consists of a poorly sorted, crudely stratified mixture of clay, silt, sand, pebbles, cobbles, and boulders.

The slide is approximately 450 feet wide at the road and 95 feet long from scarp to toe, and has a 2-foot-high head scarp. The surface of the slide is steep at 45 to 55 degrees (greater than 100 percent slope). Standing water and wet sediment are present along the toe. Parts of the slide surface are covered with crown vetch and small trees, whereas other more recently active sections are bare. A sketch and a photograph of the slide are shown in Figures 51 and 52.

This slope has apparently been continually retreating by periodic debris sliding ever since the cut was made for highway construction. A fence to keep debris off the roadway has been installed along the edge of the road at the toe of the slide.

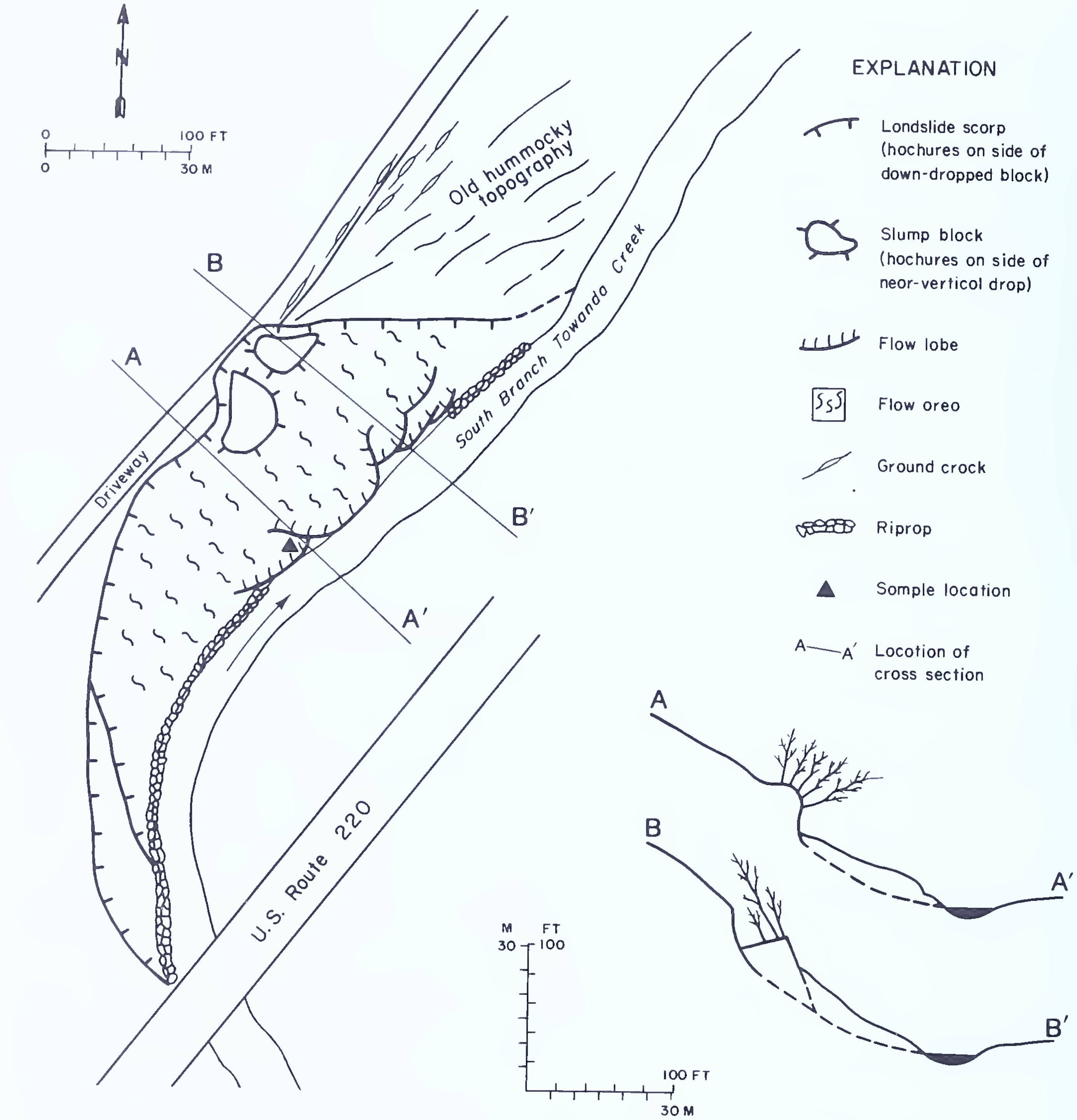

Figure 47. Sketch map and cross sections of the slide near New Albany.

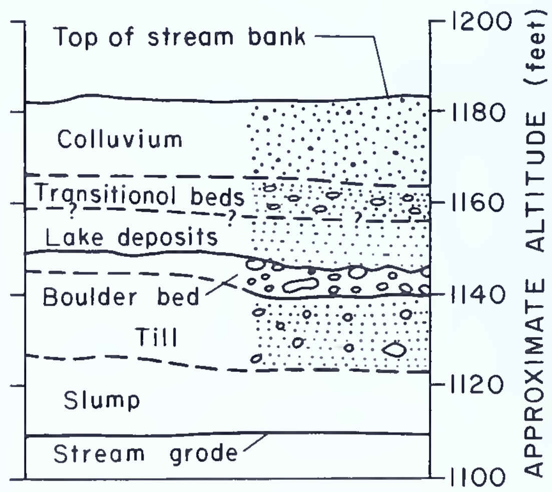

Figure 48. Sketch of an exposure of colluvium overlying stratified drift in the west bank of South Branch Towanda Creek at Stevenson, about 1.5 miles north of New Albany (from Denny and Lyford, 1963, p. 16).

Figure 49. The center portion of the slide near New Albany, showing riprap at the toe and both slump and topple blocks at the head.

IX. *Mansfield Quadrangle*

A number of similar slides in glacial-lake clay and till occur along North Elk Run in Richmond Township, Tioga County. The older slump shown in Figure 18 is located just upstream from the one discussed here, which is located on Pa. Route 660, approximately 1.5 miles west of the intersection with U.S. Route 15 (Figure 53). The slide area is a complex of active, recent, and older slumps and earthflows. Most of the toe of the slide is along the stream bank and therefore is subject to ongoing erosion. The head of one of the most active areas of slumping causes continual disturbance of Pa. Route 660 (Figures 54 and 55). Repeated repairs to the pavement and shoulder have obscured evidence of the total displacement at the head scarp.

At the southeast end of the slide area is a spectacular exposure of till overlain by glaciolacustrine clay and colluvium. The site was measured and described by Denny and Lyford (1963) (Figure 56). Figure 57 is a photograph of the same area. This bare scar is apparently maintained by shallow translational sliding of material as it weathers from the approximately 45-degree (100-percent) slope. Because the stream at the toe removes the slide material, there can be only speculation on the earlier shape and original failure mechanism of this part of the slope. The northern portion of the slide is a typical large slump-earthflow having minor active scarps and flow lobes in the body of the slide and very wet, muddy flow lobes at the toe (Figure 54). The main scarp is subdued and well covered with grass and brush. The whole slide mass is somewhat wet, but the only standing water observed was in the area just below the pavement patching. The slide appears to involve only surficial material. The glacial deposits are in contact with shaly siltstone of the De-

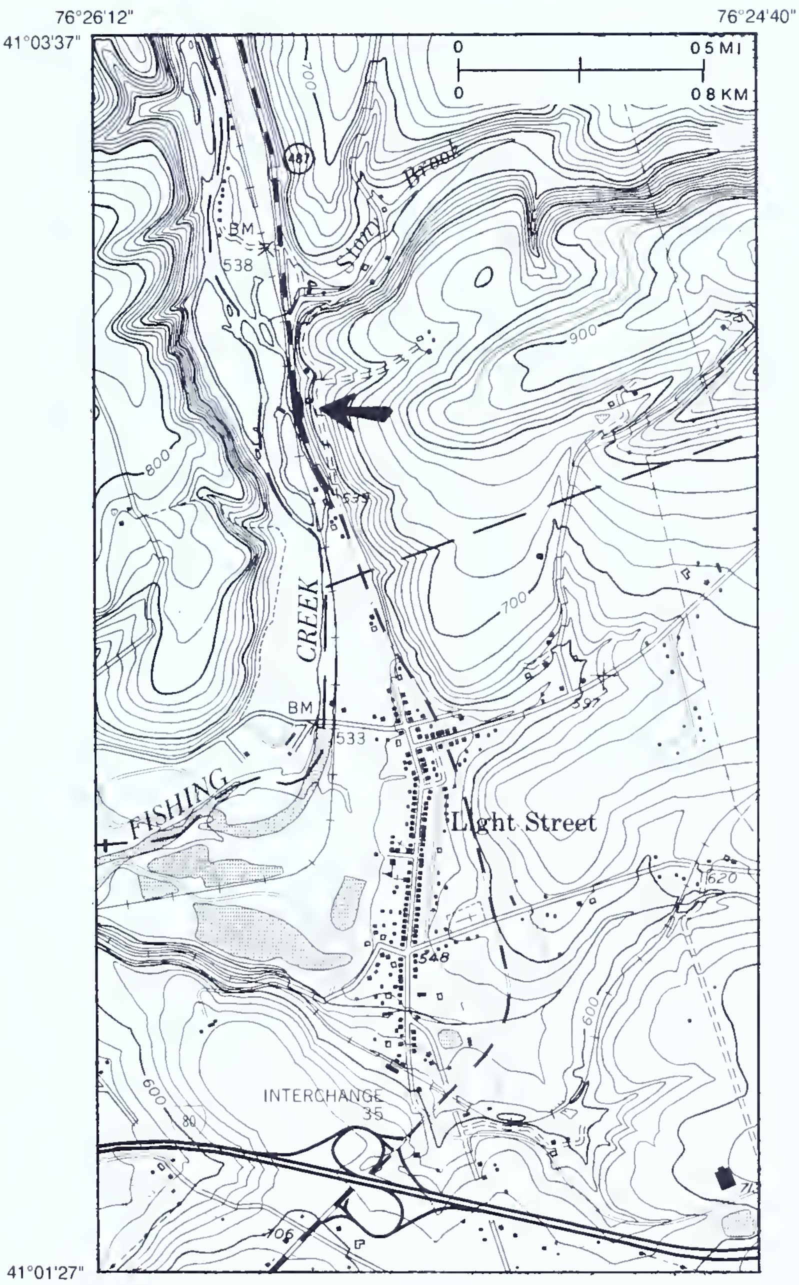

Figure 50. Location of a debris slide in glacial deposits north of Light Street on the Bloomsburg quadrangle.

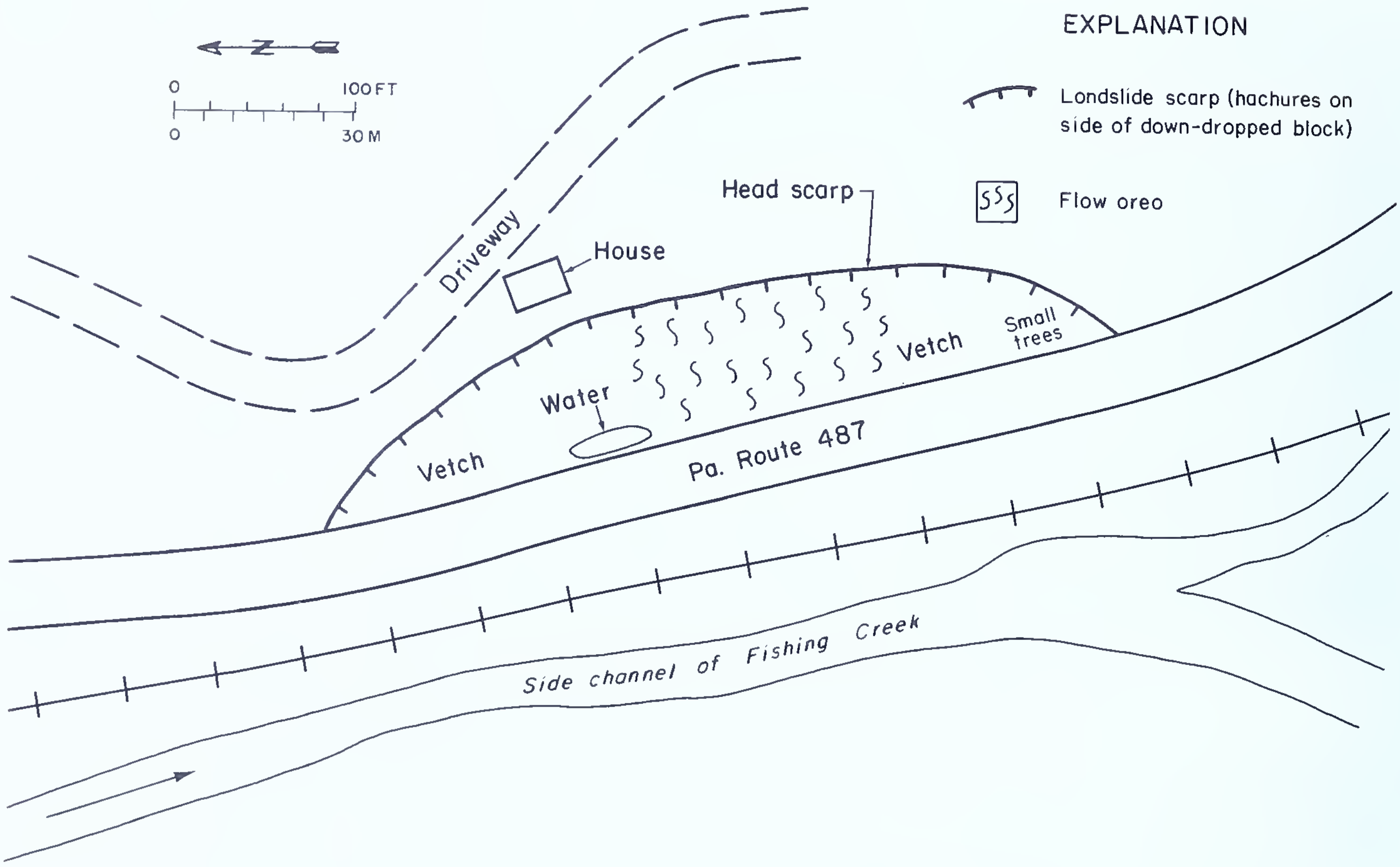

Figure 51. Sketch map of the slide near Light Street.

vonian Lock Haven Formation at the extreme southern end of the slide area. The bedrock has an attitude of N36°W, 11°SW.

This slide and the surrounding area appear to have been active landslide sites for a long time. A local resident reported that the northern part of the slide was unusually active after the heavy rain associated with tropical storm Agnes in 1972, but these slides were active earlier than that time. Most of the area for about two miles along the banks of Elk and North Elk Runs shows signs of slumping. A field check of the stream banks along North Elk Run showed that areas of extensive landsliding do not appear upstream of the highest noted outcrop of laminated clay.

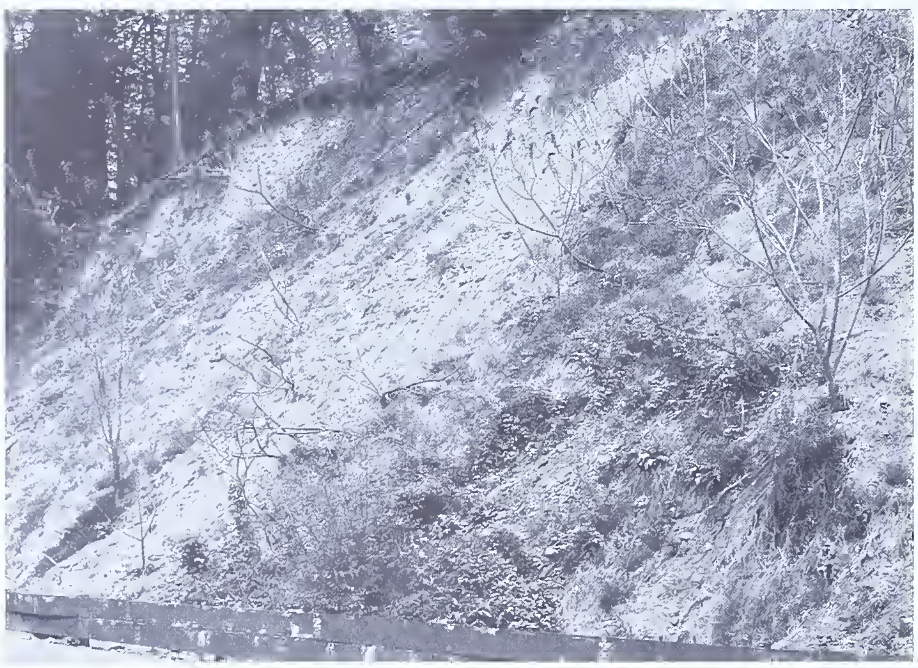

Figure 52. The central portion of the slide near Light Street.

X. Conrad Quadrangle

An ancient debris flow near Conrad, in Eulalia Township, Potter County, lies on a steep, east-facing slope above Wild Boy Run, about half a mile upstream from Sinnemahoning Creek (Figures 58 and 59). The debris flow was identified from aerial photographs by the distinctive convex form of the slide deposit. The scar, from which the slide material came, has become indistinct.

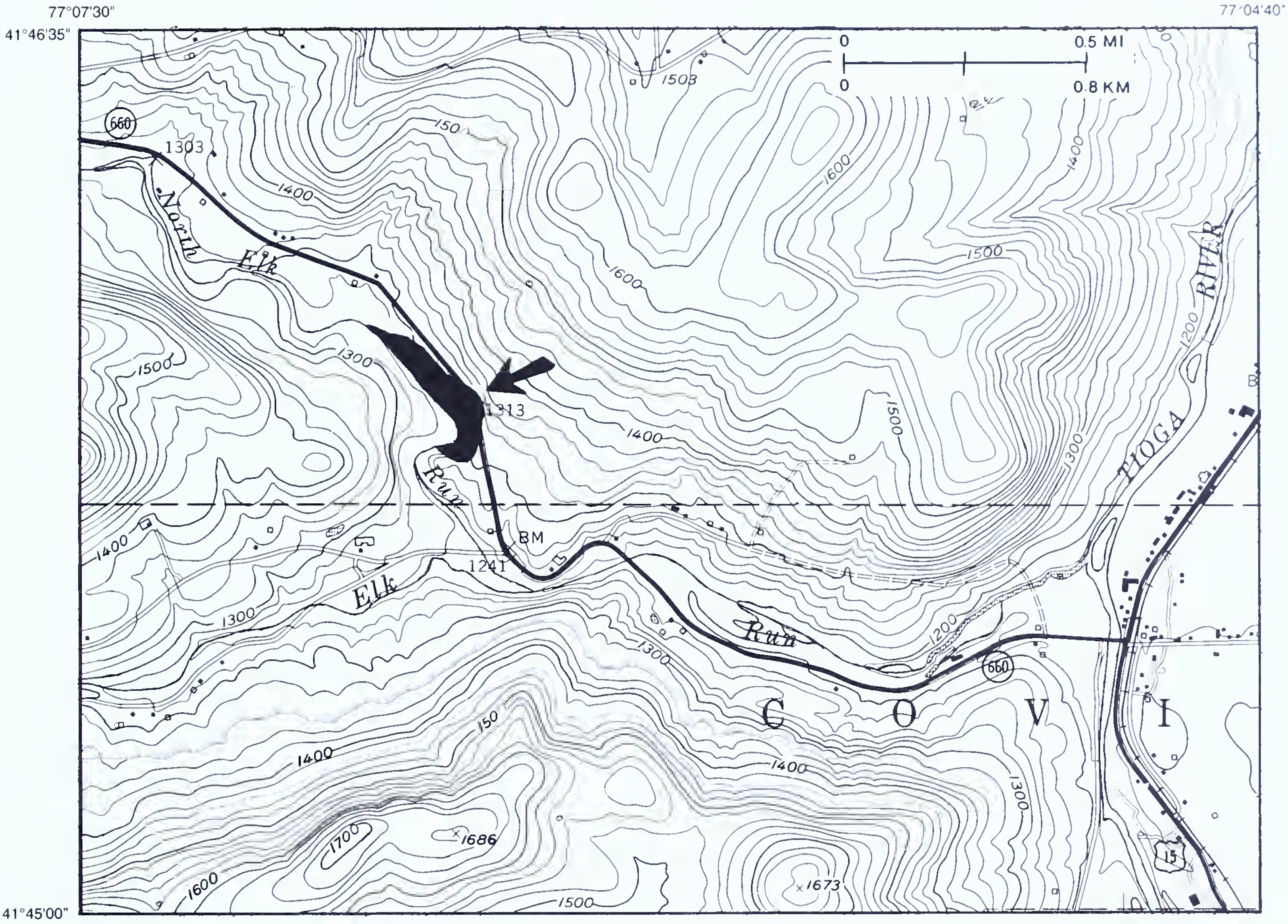

Figure 53. Location of a slump-earthflow complex west of Mansfield.

The upper edge of the slide deposit shows in the field as a break in slope that can be traced across the surface of the slide. The surface of the scar area has a slope of approximately 30 degrees (58 percent), whereas the upper portion of the deposit has a slope of 18 to 20 degrees (32 to 36 percent).

The bedrock at the site consists of nearly flat-lying rocks of the Catskill and Huntley Mountain Formations, and their contact is at approximately the same level as the top of the deposit. The surficial material on the slope is boulder colluvium derived primarily from the Huntley Mountain Formation. Visible boulders are mostly gray sandstone and range in size up to about 2 feet in diameter.

Both the scar area and the deposit are heavily forested, having trees up to 2 feet in diameter. The ground surfaces are marked by "tree-throw topography," a pattern of mounds and pits left by soil clinging to the roots of fallen trees (Figure 60). The extensive development of tree throw is an indicator that the slide is at least several hundred years old. See Denny (1956) for a more extensive discussion of this phenomenon.

The surface of the debris-flow deposit is also marked by larger scale "hummocky topography," which is typical of landslide areas (Figure 61). The toe of the old slide deposit is adjacent to the flat, swampy valley floor of Wild Boy Run (Figure 62). The toe at present appears to be the partly eroded and dissected remains of lobes that flowed out onto the flat floor of the valley. The upper surfaces of these flow lobes range from about 5 to 30 feet above the swamp at the toe.

Several small streams of water issue from the lower part of the slide deposit. At least two of these emerge from springs well back from the edge of the toe and have eroded channels into the surface of the slide.

Recent slumping of one section where the toe is about 30 feet thick was observed, but most of the toe has been stable at least long enough to allow for the growth of evergreen trees having trunks more than 1 foot in diameter. The debris flow has apparently been stable for hundreds of years, and it may be as old as late Pleistocene. Similar ancient debris flows have been identified in the Warren 1- by 2-degree map area to the west (Pomeroy, 1983, 1986).

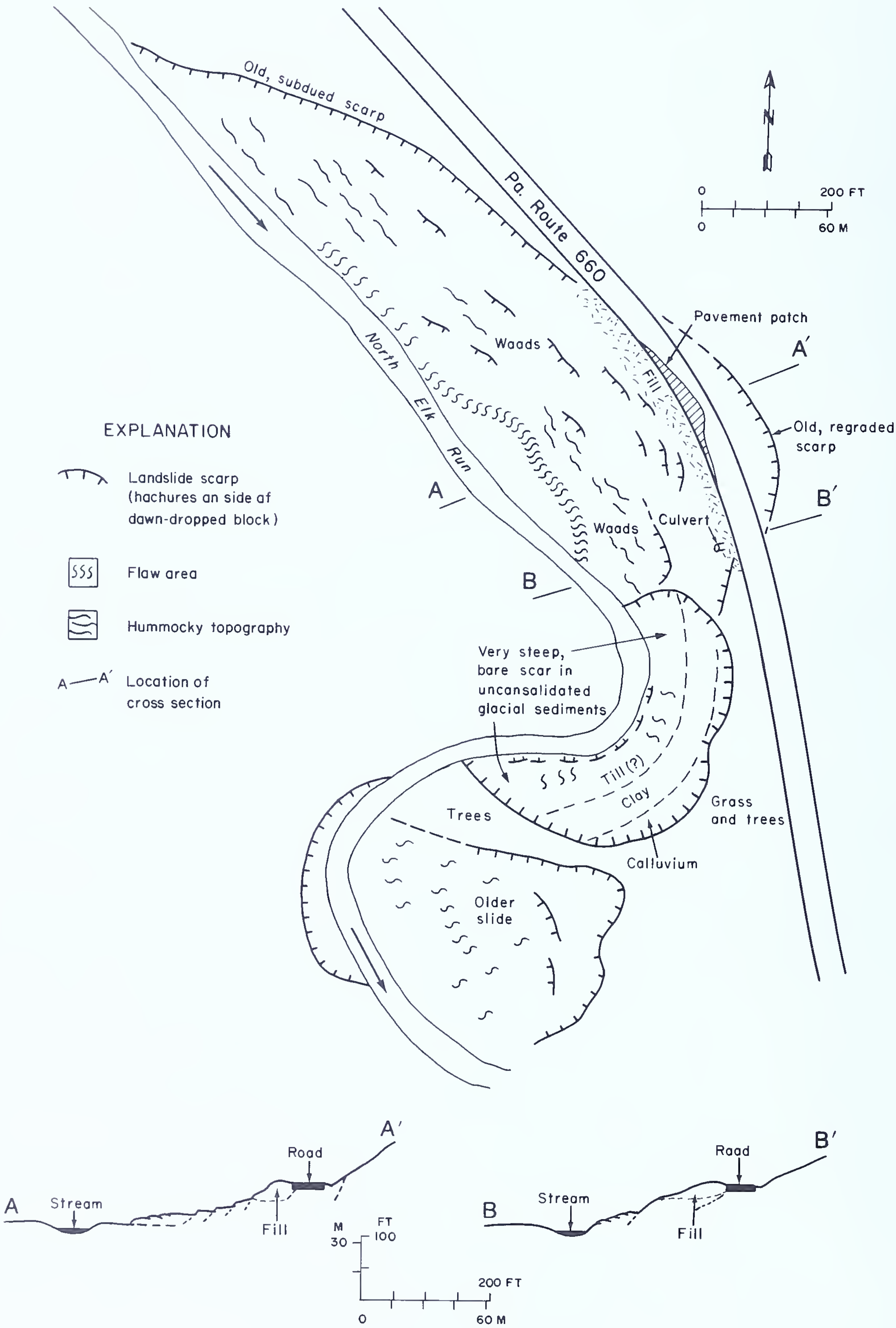

Figure 54. Sketch map and cross sections of the Mansfield slide.

Figure 55. The head scarp and associated pavement disruption of the Mansfield slide along Pa. Route 660.

XI. Keating Quadrangle

An active rockslide and debris slide in thin boulder colluvium and fractured bedrock occurs along an extremely steep southwest-facing slope above Kettle Creek and S.R. 4001, approximately 1 mile south of the Alvin R. Bush Dam (Figure 63) in Leidy Township, Clinton County. The exact date of the slide is unknown, but it is visible on the 1971 aerial photographs. The slide is presumed to be related to highway construction.

The base of the slide is approximately at the mapped level of the contact between the Devonian Catskill Formation and the Mississippian and Devonian Huntley Mountain Formation. Typical Huntley Mountain sandstone (gray, trough-crossbedded, and fine-grained) crops out on the slope west of the slide, 75 to 100 feet above the road (Figure 64). The strike is approximately N30°W, and the dip is to the northeast at less than 10 degrees (less than the angle of crossbedding). The surficial deposits at the slide site are boulder colluvium. The slope adjacent to the slide area is paved with flaggy sandstone boulders averaging 1 to 3 feet across. The colluvium is less than 10 feet thick where it is exposed in the slide scarp. The slide is on a concave slope at the outside of a sharp bend in Kettle Creek. The adjacent slopes are steep, ranging from 37 to 42 degrees.

The slide is 167 feet long and 205 feet wide at the toe. Total relief between the toe and the crown is 140 feet, and the slope of the slide surface is 45 degrees. The upper portion of the slide area is exposed bedrock and thin debris and boulder cover. The upper scarp is sharp, appears fresh, and ranges up to 10 feet in height, averaging about 5 feet. Scarps along the flanks of the slide are more subdued, rounded, and covered with crown vetch.

Two distinct, roughly triangular debris deposits occupy much of the lower part of the slide. The remainder of the slide area has a thin debris cover and supports grass, crown vetch, and a few maple saplings (Figure 65). The larger debris deposits are unvegetated except at their edges. The debris consists of flaggy, gray to gray-brown sandstone fragments (up to 4 feet long and 1 foot thick and having an average size of about 8 inches by 10 inches by 2 inches) in a red-brown matrix of sand, silt, clay, and small rock fragments and a few roots, logs, and branches.

A large volume of material has been removed from the slide area for highway maintenance. Recent removal of debris from the toe has left a steep, unvegetated face and a wet, nearly level area adjacent to the road. The stream bank below the road is steep and armored with large-boulder riprap.

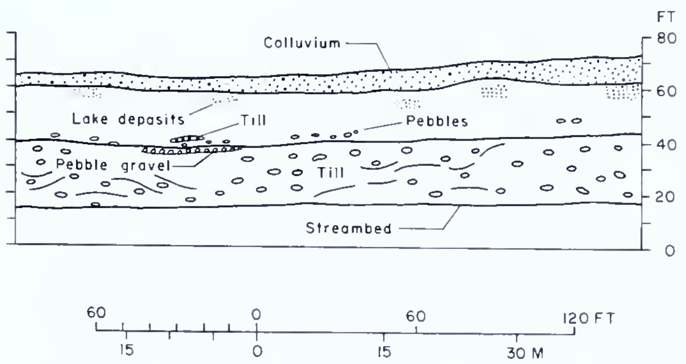

Figure 56. Sketch of an exposed section of till, lake deposits, and colluvium at the southeast end of the Mansfield slide (from Denny and Lyford, 1963, Figure 10–E, p. 16).

XII. Nanticoke Quadrangle

A recurrent flow in glaciofluvial clay, silt, sand, and gravel lies on the southeast flank of Shickshinny Mountain in Hunlock Township, Luzerne County. The flow is just above the Susquehanna River floodplain, across U.S. Route 11 from the UGI power-generating station at Hunlock Creek (Figure 66). A mudflow and debris flow blocked Route 11 during a heavy rainfall on April 16, 1983.

At this location, the Catskill Formation dips to the southeast on the northwest limb of the Lackawanna syncline. Bedrock apparently was not involved in the failure, but the dip slope and related drainage effects may have contributed to the cause of the slide.

The surficial material consists of horizontally bedded and crossbedded cobbles, sand, silt, and clay

Figure 57. Photograph of the section shown in Figure 56.

The mudflow and debris-flow deposits take the form of low fans covering and extending beyond the floor of the old quarry area (Figures 67 and 70). Sediment is poorly sorted throughout the fans, but there is rough internal stratification. Concentrations of fine sediment occur where the flows were ponded near their margins. Except in these silty areas, the surface of the fans is paved with cobbles and pebbles. The surface of the fans slopes about 8 degrees near the apex and about 6 degrees at the edges.

The most recent fan has partially buried a number of trees near its margins. The older fan to the west is covered with small trees and shrubs, which suggests that it has not been an active depositional site for at least several years. The recent fan is unvegetated, except at the edges.

The only apparent damage affecting human activities from this movement is the periodic disruption of traffic on the highway. There is the potential for loss of a support tower for the electrical transmission

deposited in a glacial delta. The slide area appears to be an abandoned sand-and-gravel quarry. The canyon-like main scarp area of the slide (Figures 68 and 69) seems to have developed along a preexisting surface-drainage channel. The walls below the scarp show evidence of seepage and piping developed along contacts between sand and underlying silt and clay beds. Some bedded sediment has nearly vertical faces, but the slope angles in loose, dry material range from about 35 to 45 degrees (70 to 100 percent slope).

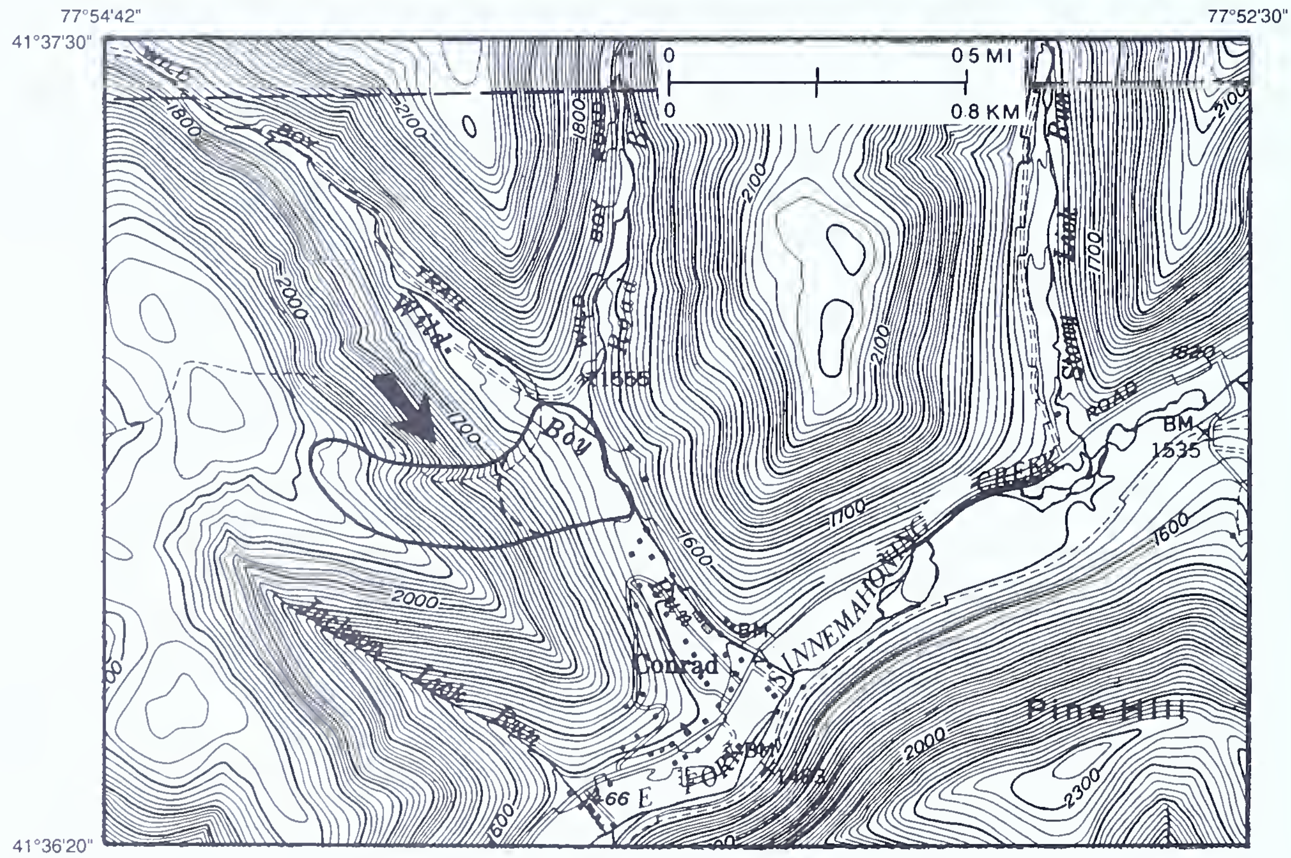

Figure 58. Location of an ancient debris flow near Conrad.

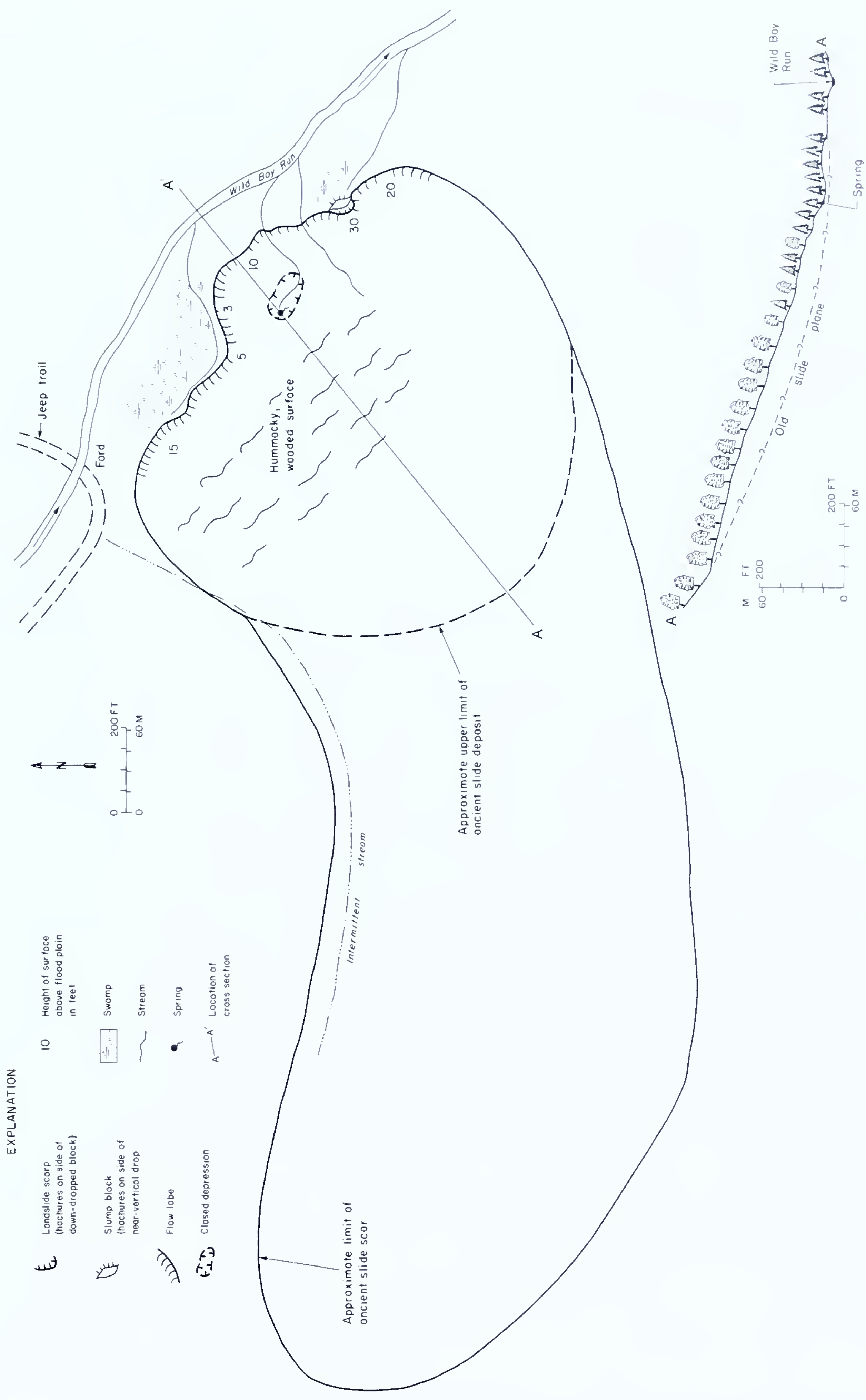

Figure 59. Sketch map and cross section of the Conrad slide.

Figure 60. An example of "tree-throw topography" on the Conrad slide. The person is standing in a pit left when a tree toppled and tore up a large mass of soil attached to the roots. As the soil was washed from the roots and the tree decayed, the mound of soil under the backpack and younger tree (center) was left behind.

line that crosses the site if the head scarp retreats farther to the north. This debris flow is unusual within the Williamsport area because of its highly fluid character. This flow falls near the high-water-content end of the spectrum of flow classifications.

XIII. Berwick Quadrangle

A debris avalanche in colluvium occurred during the heavy rains associated with tropical storm Agnes on June 21 or 22, 1972. The site is a steep, north-facing slope south of the borough of Nescopeck, Luzerne County (Figure 71). This discussion is a synopsis of an earlier description (Inners and Wilshusen, 1983).

Sandstone, siltstone, and silty shales of the Upper Devonian Trimmers Rock Formation dip to the south and are overlain by thin (less than 3 feet thick) colluvium and regolith. The colluvium is composed of bladed and platy rock fragments, oriented roughly parallel to the slope, in a very silty matrix. A sample taken near the crown consists of 48 percent gravel, 8 percent sand, 34 percent silt, and 10 percent clay.

The debris avalanche is 525 feet long and 60 to 175 feet wide at the toe, having a total relief of 280 feet. The slide extends from near the top of the slope to the base. The slope steepness ranges from 55 degrees near the crown to about 10 degrees at the toe. The plane of failure is essentially at the bedrock-colluvium interface. Field evidence, including abraded trees along the edges of the scar and the shape of the scar and deposit, suggests that failure and movement were rapid. The total volume of displaced material has been calculated to be 1,500 cubic yards. Figures 72, 73, and 74 illustrate this landslide.

The Nescopeck slide caused no known damage to roads or buildings, but nearby facilities are at risk from similar failures along the same hillside.

Landslide Inventory

The inventory portion of this study began with the inspection of aerial photographs of 63 percent of the area of the Williamsport 1- by 2-degree quadrangle (contained on 81 of the 7.5-minute quadrangles). The quadrangles

Figure 61. View downslope near the center of the Conrad slide deposit showing hummocky topography (H, hummock; S, swale).

Figure 62. The toe of the Conrad slide deposit (on the left) and the valley floor along Wild Boy Run.

included in the photo-inventory area were chosen to represent the various geologic and physiographic divisions of the area, as well as typical urban, farmland, forest, and mined areas. Figure 81 in the appendix indicates which areas were included in the photo inventory. Field checking of the photo-inventoried areas began early, to ensure that typical photo signatures were correctly identified in each of the types of terrain in the project area. Field checking of a typical quadrangle involved about a day and included driving many of the roads and making foot traverses of roadless areas, in both cases where landslides had been noted on the photographs. Time constraints and the remoteness of many parts of the study area required that much of the area not be field checked.

Other sources of data in the inventory were field observations while traveling through the area, other geologists working within the quadrangle, PennDOT, the county offices of the U.S. Department of Agriculture Soil Conservation Service, and several township and municipal governments. The inventory, therefore, includes information from quadrangles not included in the photo inventory. The data for these quadrangles are probably not as complete as those for the photo-inventoried areas, but they are a valuable addition to the total inventory.

After their identification on photographs or by other means, each landslide was drawn on the appropriate 7.5-minute topographic map and assigned a unique number. Data on the type of slide and age were noted if they could be determined. The length, width, and elevation of the head and toe of each slide were measured from the topographic maps, as was the azimuth, or compass direction, of the slope. Percent slope was calculated from the length and elevation data. The bedrock geology of each site was determined from the relevant published maps of the Pennsylvania Bureau of Topographic and Geologic Survey. The nature of surficial deposits was determined from published maps where available, and from field observation, photo interpretation, or soils maps in many other areas. The appendix contains these data for all landslides in the inventory, and it also contains reduced copies of the topographic maps showing their locations. The landslide locations are shown on Plate 1 as small dots.

Analysis of the inventory data involved separation of the landslides into groups based on landslide type, and tabulation of each recorded factor for each type. The distribution of 1,349 identified landslides by slide type is shown in Figure 75. The high proportion of composite slides reflects in part the number of slides for which the type could not be determined on the aerial photographs.

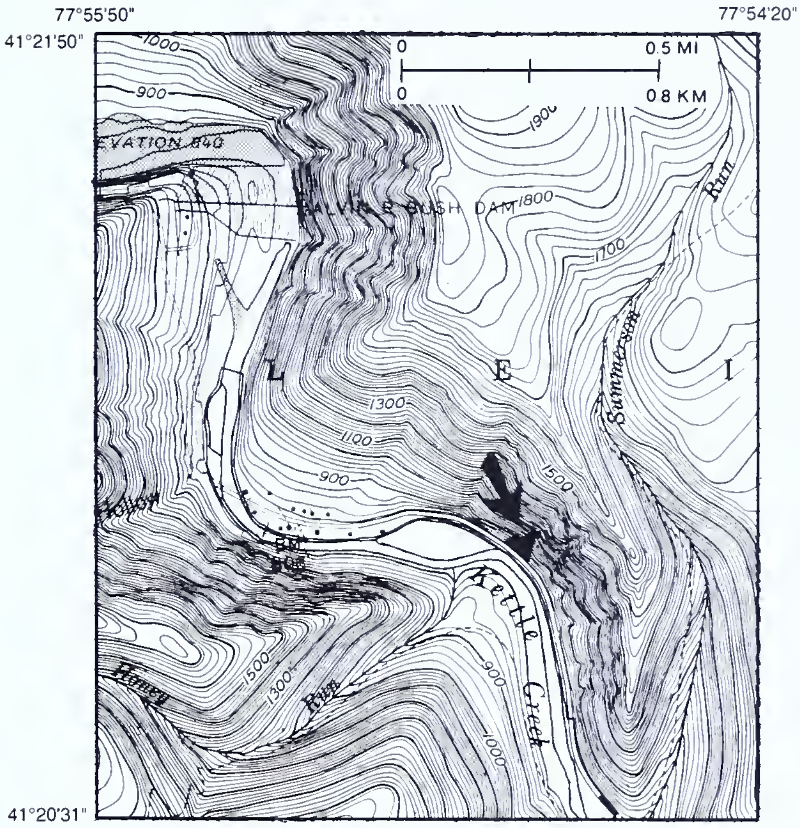

Figure 63. Location of a debris slide along Kettle Creek on the Keating quadrangle.

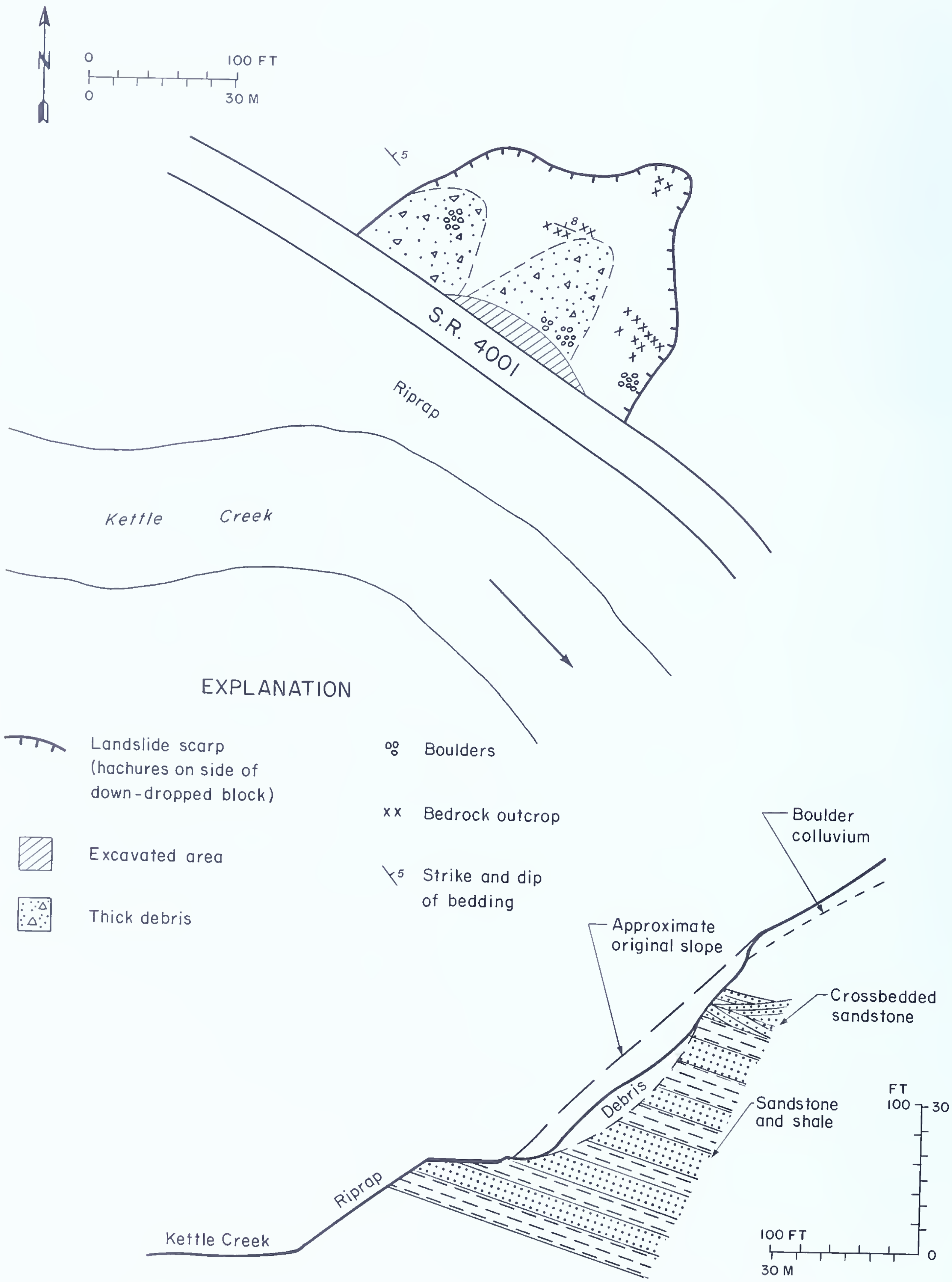
N
0
100 FT
0
30 M
5
8
S.R. 4001
Riprap
Kettle
Creek
EXPLANATION
Landslide scarp (hachures on side of down-dropped block)
Excavated area
Thick debris
Boulders
Bedrock outcrop
Strike and dip of bedding
Boulder colluvium
Approximate original slope
Crossbedded sandstone
Debris
Sandstone and shale
Riprap
Kettle Creek
FT
100
30
0
100 FT
30 M

Figure 65. Photograph of the Kettle Creek slide from across the road.

FACTORS THAT AFFECT LANDSLIDING

Every landslide is caused by a number of factors acting in combination to either increase effective shear stress or decrease resistance to shear on a slope. Although most factors affecting the stability of a slope are interrelated, they can be divided into four main categories: geology, topography, water, and human activity.

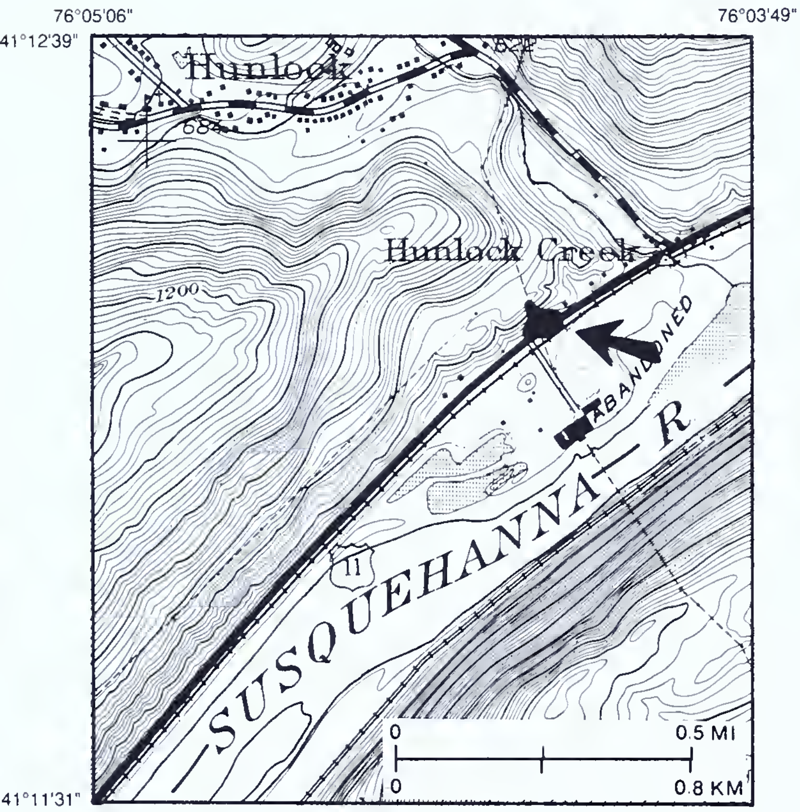

Figure 66. Location of the Hunlock Creek debris flow on the Nanticoke quadrangle.

GEOLOGY

Bedrock

The most apparent geologic factor affecting slope stability is the nature of the bedrock. The strength of unweathered rock, porosity and permeability, susceptibility to weathering, and characteristic weathering products can all be related to lithology. All of the rocks exposed in the Williamsport map area are sedimentary. Shales and claystones are relatively weak and impermeable and weather to produce clays. Sandstones are generally strong and permeable, although both of these characteristics depend on the degree of cementing and fracturing of the rock. Paradoxically, it is the relative resistance of sandstones that allows the development of steep cliffs and cuts that can be prone to rockfalls. More important than the rock type of any individual bed is the arrangement of different lithologies. Where an otherwise strong, massive sandstone is underlain by easily weathered shale, an undercut condition can develop, possibly leading to failure. A single thin shale layer can limit water movement through more permeable rock and trigger failure of a large section of slope.

Sedimentary structural features that can affect landslide potential include bedding thickness and regularity, changes in attitude due to large-scale cross-bedding, channel structures or other erosion surfaces, and postdepositional compaction features. Vertical or lateral variations in grain size or mineral composition can cause variations in weathering characteristics and groundwater movement, thereby affecting stability. Most of these factors are localized and can only be determined by detailed field investigation of a specific site. Mappable rock units (formations), however, tend to have similar characteristics over a fairly large area and allow generalized predictions about the likelihood of landslide problems to be made, based on geological mapping.

The distribution of various types of landslides in the Williamsport map area for each bedrock unit is shown in Figure 76. Because many slides originating near formation boundaries are large enough to involve rocks of two different map units, these transition zones

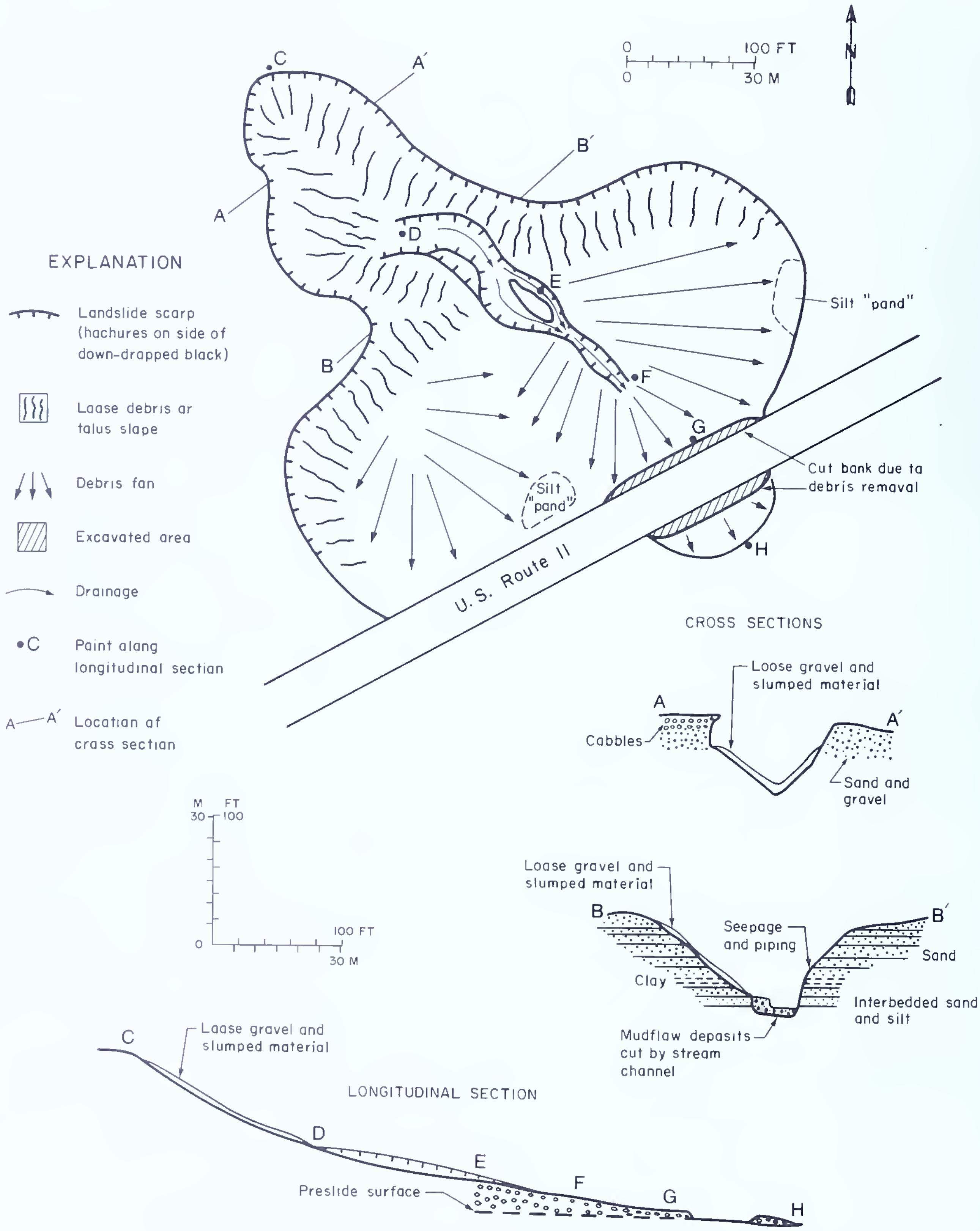

Figure 67. Sketch map, longitudinal section, and cross sections of the Hunlock Creek debris flow.

were treated as separate units in the landslide analysis. As pointed out by Lessing and others (1983) in their discussion of a detailed statistical correlation of 12 landslide factors, frequency histograms can be misleading unless they are considered in light of the areal distribution of the factors. The bedrock units in the Williamsport area most strongly associated with landslide occurrences are the Huntley Mountain, Catskill, and Lock Haven Formations and the transitions between them. These rocks underlie 85.8 percent of the total number of slides. If this figure is divided by the percentage of area occupied by the three formations, 64.3 percent, the result suggests that 1.33 times as many slides occur on these units as would occur if bedrock geology was not a controlling factor in slide distribution. Because the data-collection methods are

Figure 68. The head-scarp area of the Hunlock Creek debris flow showing glaciofluvial sand and gravel in the upper section. The upper part of the debris fan and incised channel are visible in the foreground.

not statistically equivalent over all parts of the study area, the type of analysis used by Lessing and others (1983) was not attempted here.

It is, however, useful to consider the areal distribution of bedrock when looking at the distribution of landslides. Planimeter measurements from the *Geologic Map of Pennsylvania* (Berg and others, 1980) yielded the results summarized in Figure 77. For debris avalanches and debris flows, many of which occur in the deeply incised valleys in the Appalachian Plateau, the Huntley Mountain and Catskill Formations appear to be the most susceptible units. Debris slides show an apparent bias toward occurring in the Catskill and Huntley Mountain Formations. The Huntley Mountain Formation and the Mississippian sandstones seem to be involved in a disproportionate number of rockfalls and rockslides. The strong association of slumps and slump-earthflows with the Lock Haven, and to a lesser degree, the Catskill, is probably a reflection of the coincident distribution of glacial deposits over these bedrock units, since most slumps and slump-earthflows are in tills and glacial-lake clays. Bedrock geology influences till composition, and so should not be entirely dismissed here, however. The Catskill and Huntley Mountain Formations again appear to be the primary bedrock units involved in composite landslides.

The specific characteristics of these units that cause landslides have not been identified with certainty, but they are believed to be related to the high proportion of red shale and claystone in parts of the Huntley Mountain and Catskill Formations, and to the arrangement of sandstone and shale interbeds.

Structure

A second important category of geological factors affecting landsliding includes those related to structural features of the rocks, including joints, folds, and faults. Joints are fractures in rock. They may be vertical, horizontal, or at any orientation in between, and may have any orientation relative to bedding. Joints generally occur in more or less parallel sets, and several intersecting sets are commonly present. The spacing and orientation of joints are controlled by the patterns

Figure 69. View down from the head scarp across the gully and debris fan of the Hunlock Creek debris flow.

Figure 70. Debris fan at Hunlock Creek, looking upslope from U.S. Route 11 across the apex of the fan to the scarp area.

of deformational forces acting on the rock mass. Joints are most important to landsliding as discontinuities along which blocks of rock can separate from the main rock mass. They also act as pathways for groundwater flow and associated increased weathering.

The presence of folds in rock strata affects landslide potential in several ways. The inclined attitude of bedding in folded rocks is usually obvious, and inclined bedding planes are probably the most common failure surfaces in bedrock slides. The orientation of bedding planes and joint surfaces controls groundwater-flow patterns in ways that can either increase or reduce stability. Folds are also important because of the way the pattern of deformational forces affects joint formation. Joints tend to be more intensely developed along the axial planes of folds, leading to weaker zones of closely-spaced fractures there.

Faults are fractures in rock along which movement has occurred. The zone around the surface of movement is generally much more intensely fractured than the surrounding rock. The combined effects of shearing motion along the fault and increased weathering in the zone of fracturing frequently lead to development of a major zone of weakness along a fault. Faulting occurs on large, intermediate, and small scales, and identification and mapping of fault zones can be an important part of identification of landslide-risk areas.

In considering the stability of bedrock slopes, the most important factor is the nature and orientation of any discontinuities, including joints, bedding planes, faults, or other surfaces of potential failure. If a fault surface is smooth and polished from earlier movement, it is less resistant than an irregular, wavy joint surface. A thin, even layer of weathered shale between two massive sandstone beds is more likely to act as a slide plane than a sandstone contact without the interbed. Bedrock having many closely spaced joints is weaker than a similar unit having fewer fractures. The orientation of discontinuities relative to the hillslope is critical. Horizontal bedding is generally fairly stable, but a gentle dip out of the slope can greatly reduce the stability. Combinations of fractures and bedding orientations can lead to very serious rockfalls and

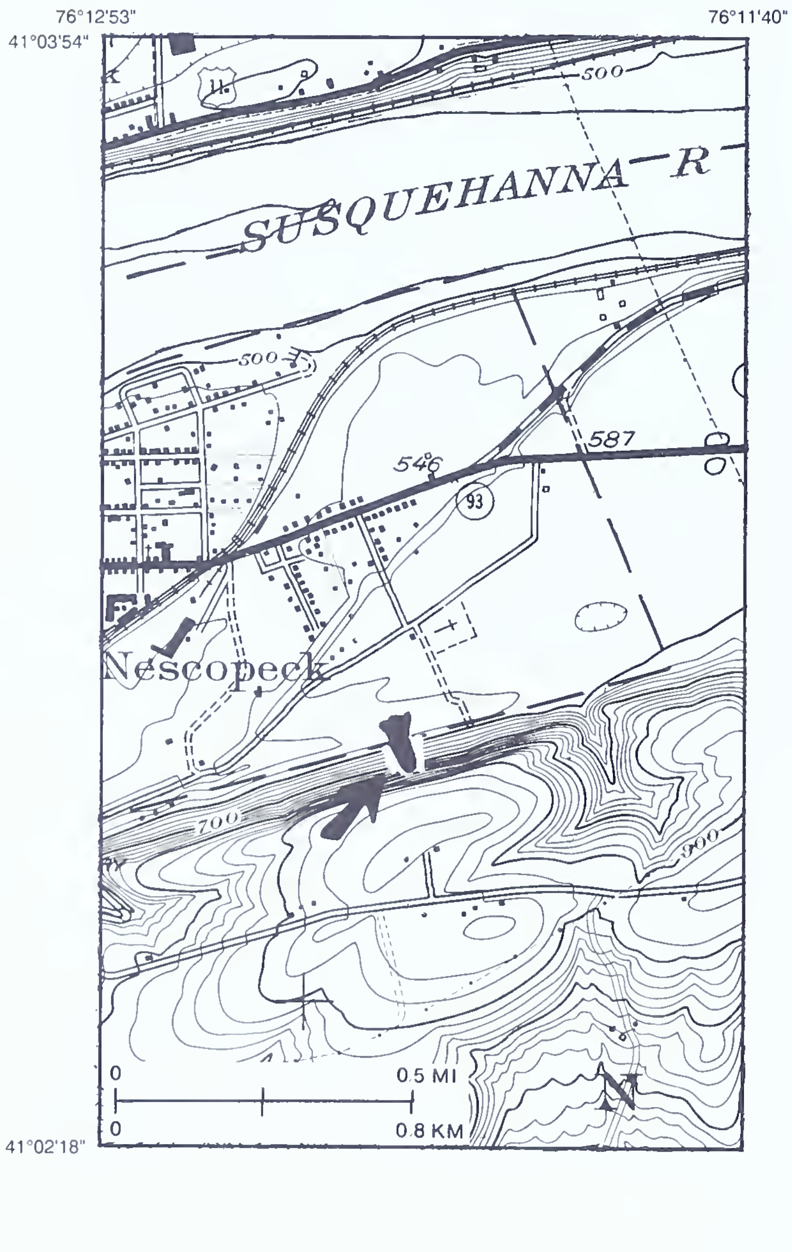

Figure 71. Location of the Nescopeck debris avalanche on the Berwick quadrangle.

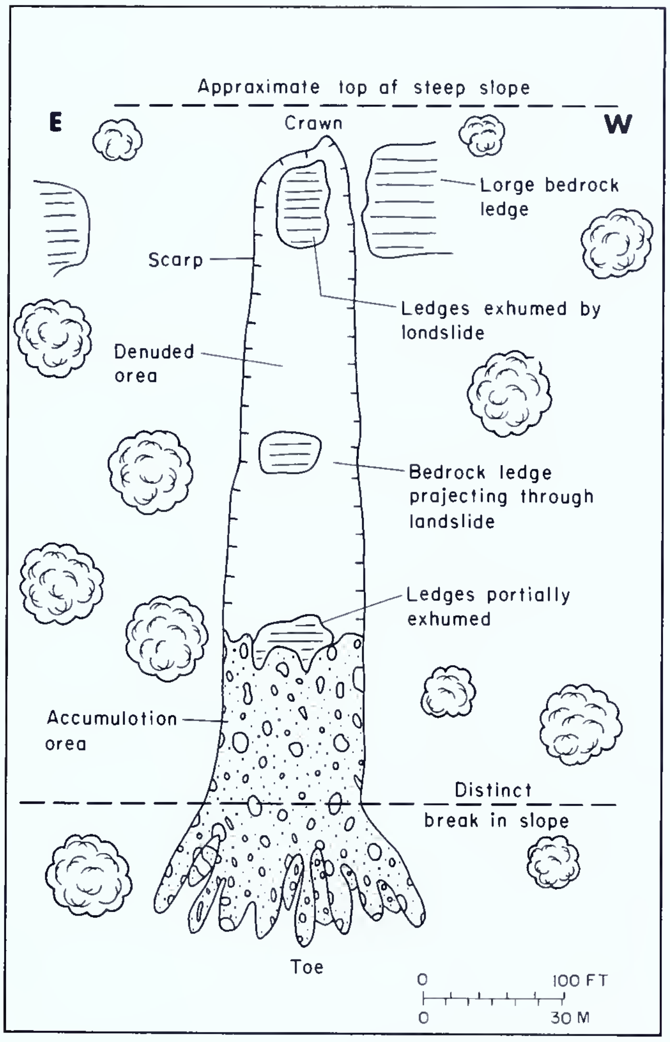

Figure 72. Sketch map of the Nescopeck debris avalanche (from Inners and Wilshusen, 1983, p. 13).

wedge-failure-type rockslides (see Figure 13). Bedding and joints that are interconnected and dip out of a slope may allow excess water to drain from permeable rocks, thereby increasing stability, or the same structural situation may lead to increased weathering of shaly rocks, producing more clay along a potential slide plane. Discontinuities that are interconnected but do not allow for free drainage can lead to a local increase of water pressure, decreasing the stability.

Surficial Geology

The final type of geological factor affecting landsliding is the nature of the surficial deposits or unconsolidated material overlying the bedrock. Surficial deposits include material derived from weathering of bedrock but still in place, material moved a short distance downslope by soil creep or similar processes, and sediments transported significant distances from their source by water or glacial ice. The composition of all these materials is related to the composition of the bedrock from which they are derived. Transport for great distances or long exposure to soil-forming processes can winnow out fine-grained sediments from gravel or develop zones of leaching and enrichment of clays and soluble minerals. Surficial deposits are less likely to be affected by structural deformation than is bedrock, but the existence of discontinuities within a mass of sediment can have similar effects on stability. Bedding planes and depositional contacts are common failure surfaces, as are the contacts between residual or colluvial soils and relatively unweathered bedrock.

Water affects different unconsolidated sediments in different ways and to varying degrees. Loose sand becomes more stable when it is moistened but loses its resistance to sliding with the addition of more water. Clays generally undergo a decrease in shear strength as their water content increases, and smectite and some other clay minerals also swell when wet, reducing stability even further. Minor changes in the chemistry of clay/water systems can have large effects on their strength and stability (Fisher and others, 1968).

The behavior of mixtures of clay, silt, sand, and gravel depends on the proportions and distributions of the components. Laminated clays deposited in glacially dammed lakes cause many landslide problems, whether they are at the surface or buried under thick deposits of later sediments. Lake clays are common in some of the valleys within the glaciated part of the study area, but exposures are discontinuous and the extent and thickness of the deposits are not known in detail. Maps of geomorphic features and glacial deposits in the Cowanesque River valley (Coates, 1966) illustrate the complexity typical of some of these materials. Lacustrine clays are known from the valleys of the Cowanesque and Tioga Rivers, the main branch of the Susquehanna

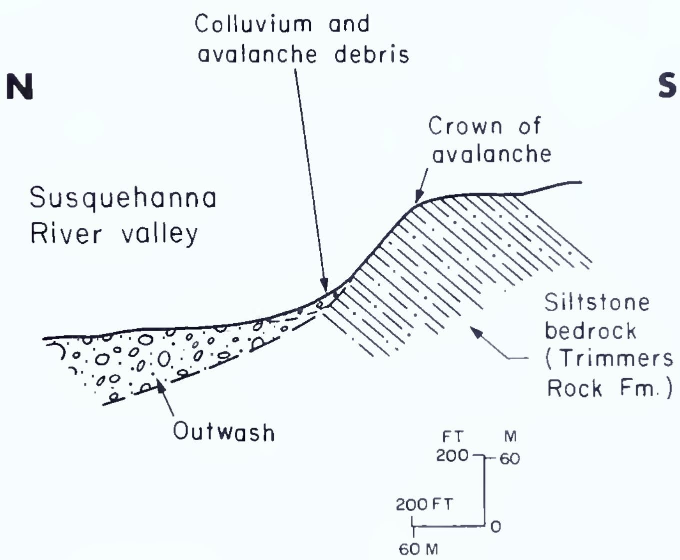

Figure 73. Cross section of the Nescopeck debris avalanche.

Figure 74. Photograph of the Nescopeck debris avalanche from below.

River, and their tributary streams (Willard, 1932; Denny and Lyford, 1963; and Coates, 1966).

Clay-rich glacial tills are involved in about 19 percent of the slides for which surficial materials were identified. Tills seem to be more of a problem where they are thick and where they have been disturbed by road building or other human activity. Glacial deltas, kames, kame terraces, and other deposits formed by flowing water associated with glaciers occur throughout much of the area but can be so internally variable that it is difficult to generalize about their susceptibility to landsliding. Where they contain large amounts of clay or silt, or are in an unfavorable setting relative to other factors, these glaciofluvial deposits can be very prone to landsliding. Thickness and distribution of glacial deposits are partially controlled by preglacial topography. In a study of landslide potential near the Tioga and Hammond Dams, Gilbert Associates (1979, p. 3) found that "buried pre-glacial valleys and deep bedrock gorges now filled with thick glacial and colluvial deposits which are behind the present valley walls were determined to be the most susceptible to landsliding." Because the distribution of these deposits is difficult to determine or map on a regional scale, it is safer to treat areas where these units occur as slide prone until detailed information indicates otherwise.

Nearly all of the slopes in the unglaciated portion of the area, and many within the glacial border, are covered with colluvium. This material is unsorted and derived from the bedrock or older surficial deposits. Its texture ranges from silty clay loam having only a few rock fragments to mixtures of angular rock fragments having very little matrix (Denny and Lyford, 1963). The coarse, rubbly colluvium is generally derived from massive sandstones in areas of high relief, such as the Mississippian and Pennsylvanian sandstones in the Appalachian Plateaus province (see Table 3) or the Tuscarora sandstone in the Ridge and Valley province. Colluvium developed on shales and siltstones may be made up of distinct rock fragments or may have weathered to clay and silt. On the interbedded sandstones, siltstones, and shales of the Catskill and Huntley Mountain Formations, colluvium typically consists of medium to large fragments of sandstone in a matrix of deeply weathered, fine-grained material.

The thickness of colluvial deposits in the study area ranges from very thin to several tens of feet thick. Deposits generally are wedge shaped, and the greatest thicknesses are on the lower slopes. Very thick colluvial deposits are typically developed on slopes of high relief within about ten miles of the border of Pleistocene glacial activity. Much of this colluvium is believed to have developed due to the intense peri-

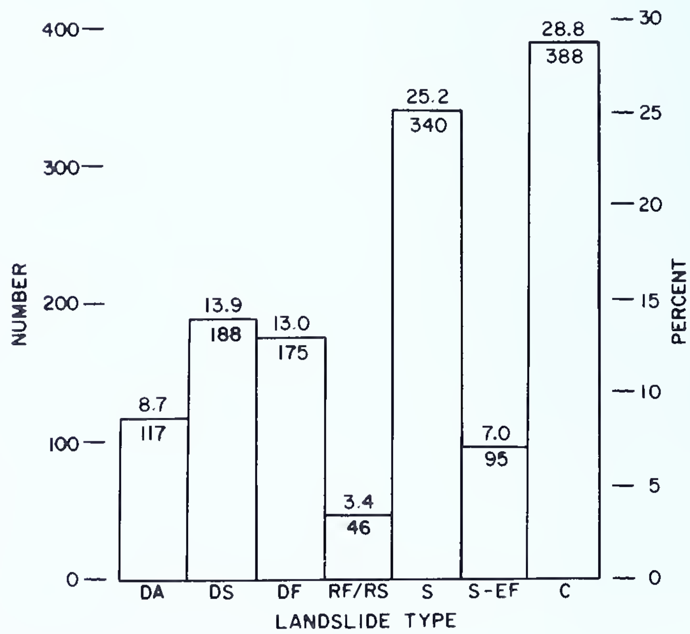

Figure 75. Distribution of inventoried landslides by landslide type. DA, debris avalanches; DS, debris slides; DF, debris flows; RF/RS, rockfalls and rockslides; S, slumps; S-EF, slump-earthflows; C, composite or unknown slides; number within bar, number of landslides for each type; number above bar, percentage of landslides for each type.

glacial weathering conditions associated with the Wisconsinan glacial stage and primarily resulted from mass movement during deglaciation. These deposits have different characteristics depending on their geologic and topographic situation. One type of setting is illustrated by a site on Bald Eagle Mountain, southeast of Lock Haven (see Figure 5). High on the north face of the mountain is a stable boulder field of Tuscarora sandstone boulders. On the lower slope below the boulder field are thick deposits of colluvium resting on older deposits that may be pre-Wisconsinan tills. The surface form of the colluvial deposits suggests that they are very old landslide deposits and may be related to the boulder field above them (Figure 37). The boulder field is considered to have developed under periglacial conditions. Highway construc-

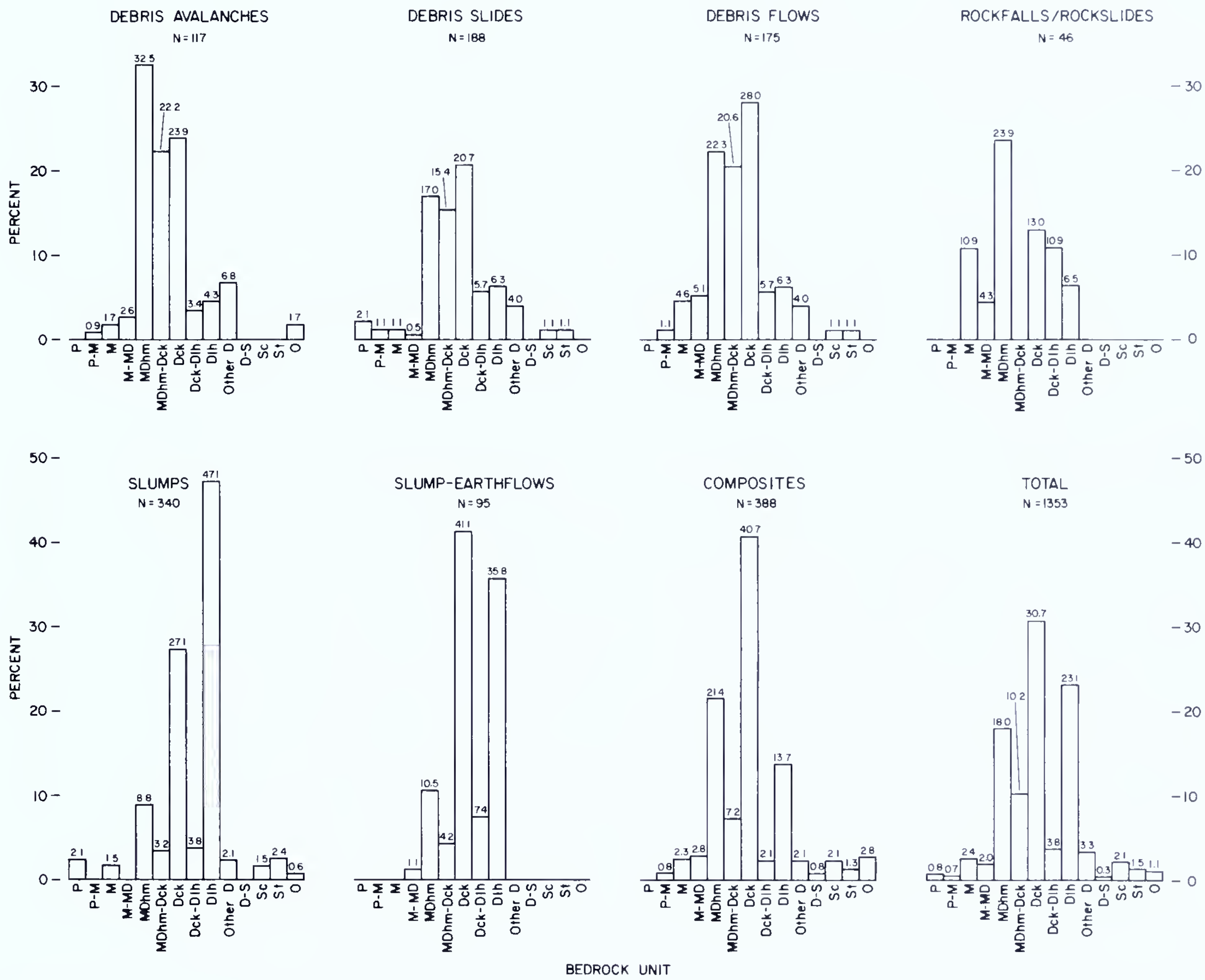

Figure 76. Frequency distribution of landslides by bedrock geology for each landslide type. Some bedrock units from Berg and others (1980) and Table 3 are grouped for ease of handling. P, Pennsylvanian-age sandstones—Llewellyn and Pottsville Formations; P-M, rocks near the Pennsylvanian/Mississippian transition, mostly sandstone and minor shale; M, Mississippian—Mauch Chunk Formation, Burgoon Sandstone, and Pocono Formation; M-MD, rocks near the contact between the Burgoon Sandstone and the Huntley Mountain Formation or Rockwell Formation; MDhm, Huntley Mountain Formation; MDhm-Dck, rocks spanning the transition between the Huntley Mountain and Catskill Formations; Dck, Catskill Formation; Dck-Dlh, rocks spanning the contact between the Catskill and Lock Haven Formations; Dlh, Lock Haven Formation; other D, other Devonian-age rocks, mostly siltstone and shale; D-S, rocks spanning the Devonian-Silurian transition, mostly limestones and shales; Sc, Clinton Group and its upper and lower transition zones; St, Tuscarora Formation; O, various units of Ordovician age.

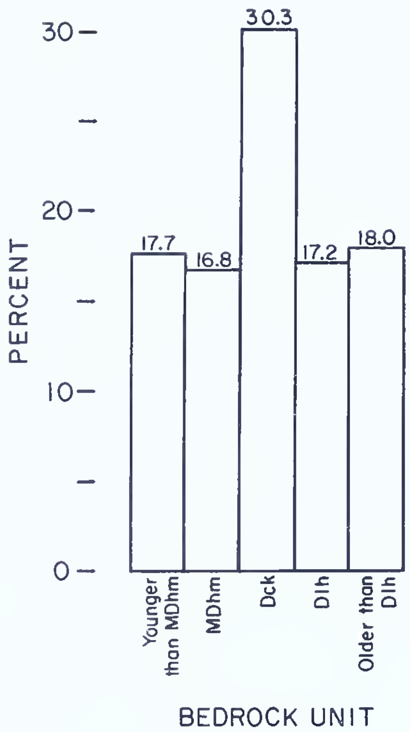

Figure 77. Percentages of the area of the Williamsport 1- by 2-degree quadrangle underlain by the bedrock units most associated with landslides. Map units younger than the Huntley Mountain Formation and older than the Lock Haven Formation are grouped. MDhm, Huntley Mountain Formation; Dck, Catskill Formation; Dlh, Lock Haven Formation.

tion for the Lock Haven bypass cut into the colluvial slope and resulted in very costly landslide problems.

Another typical colluvial setting related to periglacial activity in the study area is that of the relict debris flows described by Pomeroy (1983, 1986) in the Warren 1- by 2-degree quadrangle to the west. Large debris flows in sandstone and shale colluvium occur on moderately steep slopes having high relief. Similar debris flows occur in the Williamsport quadrangle, especially in the western portion, in the Deep Valleys section (see detailed information concerning one of these debris flows near Conrad on p. 40–41). New debris flows of this magnitude are not likely to occur under the present climatic conditions, but the old landslide deposits can be unstable if they are disturbed. The concavo-convex landforms described by King and Coates (1973) in the Susquehanna Great Bend area, northeast and east of the Williamsport quadrangle, may represent roughly analogous activity in glaciated terrain.

The colluvial deposits on most slopes are thinner than the deposits in these extreme examples, ranging up to several feet thick. Where other factors, such as steepness, construction activity, or the presence of water, combine to reduce stability, these colluvial slopes are especially prone to debris slides, flows, and avalanches.

A special category of colluvial deposits is old slump and slide deposits. Simple logic suggests that after a slope has failed by landsliding, the forces driving the slide should be reduced, and the slope should be relatively stable. This is only sometimes true. Once shear failure occurs in most clay-rich soils, the material along the planes of slippage is significantly weaker than the original soil mass. Only minor changes in loading or water conditions are required to reactivate the slide in these situations.

The quality of information on the distribution of types of surficial material varies within the Williamsport quadrangle. For some areas, detailed surficial geological maps are available, while for others, only reconnaissance surficial mapping has been done. Several workers (Ott, 1979) have attempted to correlate landslide potential with map units from the U.S. Department of Agriculture soil survey maps. This methodology appears to be a useful approach for small areas, but the wide variety of named soil series over an area as large and varied as the Williamsport map area, and the lack of continuity between soil surveys of different counties, which were prepared at different times, made examining soil types an unmanageable task for this project. However, soils maps can be useful in the preliminary identification of some types of surficial deposits. In Tioga County, for example, areas mapped as "Volusia silt loam with silty substratum" can be correlated with areas showing slope failures in glacial-lake clays.

The distribution of landslides by surficial material is shown in Figure 78. The large "unknown" column in each graph reflects the gaps in information concerning the distribution of surficial deposits in the area. Debris avalanches and debris flows occur almost exclusively in colluvium and boulder colluvium. Debris slides typically involve these materials, but also occur in till, other glacial deposits, rock, and fill or mine spoil. Rockfalls and rockslides by definition involve in-place rock, but a number of slides also involve overlying colluvium or boulder colluvium. Slumps and slump-earthflows develop primarily in glacial deposits. Glacial-lake clays are the most common medium for slumps, which typically occur along stream banks, where erosion at the toe can cause progressive failure. Till, other glacial deposits, and colluvium account for the rest of the slumps and most of the slump-earthflows. The similarity of the graphs for composite slides and the total of all slides suggests that the composite category represents a fairly even contribution from all the basic types.

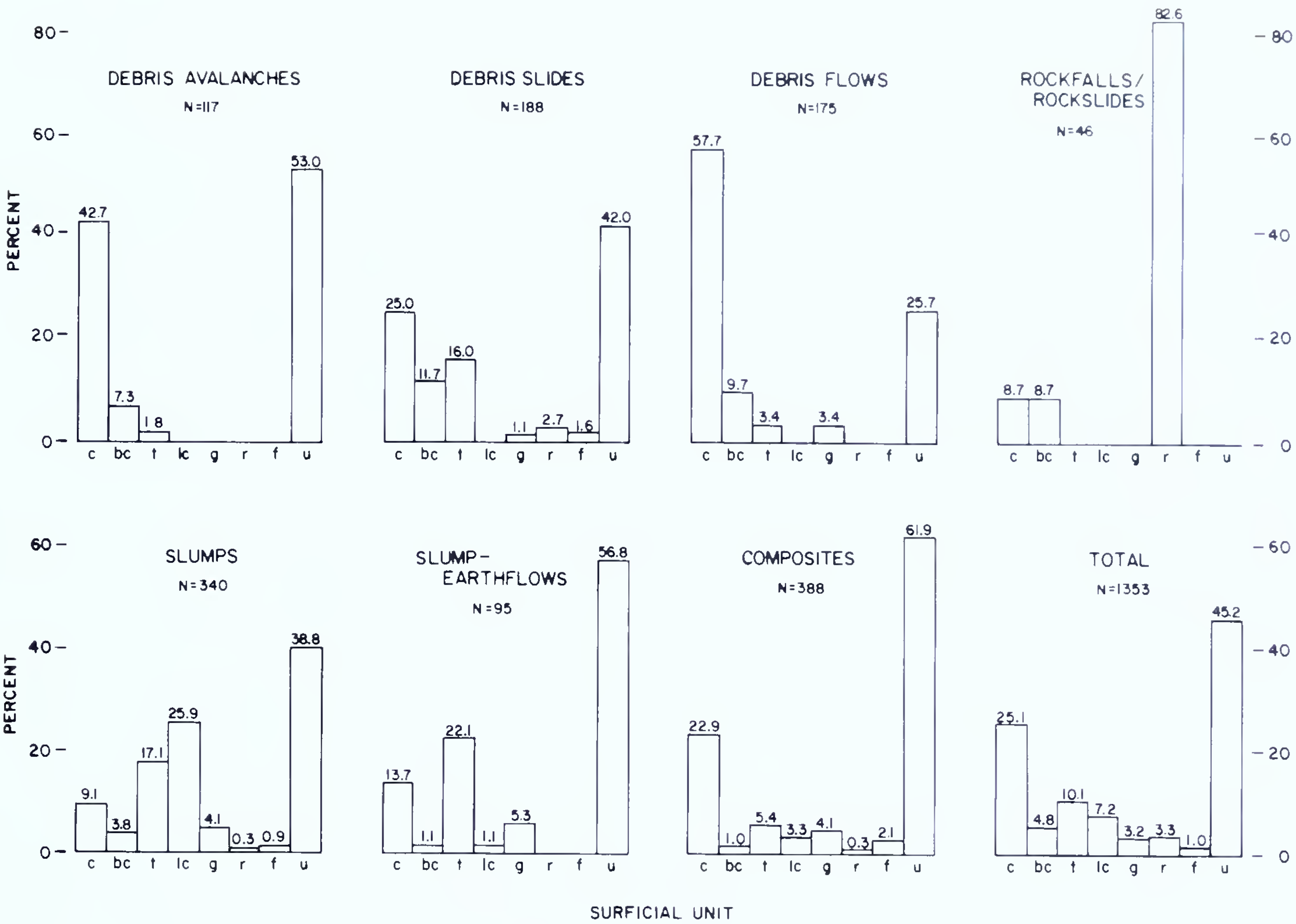

Figure 78. Frequency distribution of landslides by surficial material for each landslide type. C, colluvium; bc, boulder colluvium; t, till; lc, glacial-lake clay; g, other glacial deposits (kames, deltas, and outwash); r, rock having thin or no cover; f, artificial fill or mine refuse; u, unknown or other.

TOPOGRAPHY

Characteristics of the shape of the land surface constitute the next major category of factors affecting landslide potential. That steeper slopes should be more susceptible to sliding seems obvious, but this is true only for slopes developed on the same materials. Strength and resistance of bedrock and soils to sliding are critical factors in the development of slopes, and materials vary in their capability to support a steep slope. A grade of 30 percent (30 feet of vertical change in 100 feet horizontally) is quite steep for clay-rich unconsolidated material, but not particularly so for sandstone bedrock having thin residual soil.

Within the Williamsport quadrangle, landslide types can be divided into three groups based on the distribution of slope steepness. Figure 79 shows frequency distributions of numbers of slides by slope steepness for each slide type. Rockfalls and rockslides are most likely to occur on the steepest slopes; about 50 percent occur on slopes steeper than 50-percent grade and none occur on slopes gentler than 20 percent. Debris avalanches and debris slides comprise the next group, and most of these slides (82 percent of debris avalanches and 66 percent of debris slides) occur on moderately steep slopes, between 20 and 70 percent grade. Slumps, slump-earthflow combinations, and debris flows are most abundant on fairly gentle slopes; about three quarters of them occur on slopes of less than 30 percent. These differences reflect the nature and distribution of the materials involved in the slides. Most slumps and slump-earthflows involve glacial-lake clays, tills, and other glacial deposits that are associated with gentle to moderate slopes. Most debris flows are old, large features and the flows themselves are generally partly responsible for the gentle slope. The slides on moderate slopes typically involve colluvium, boulder colluvium, or till, whereas the steep slope failures are more likely to be in bedrock, residual soils, or boulder colluvium.

Winters (1972) found that the position of a susceptible rock unit on a slope affected the potential

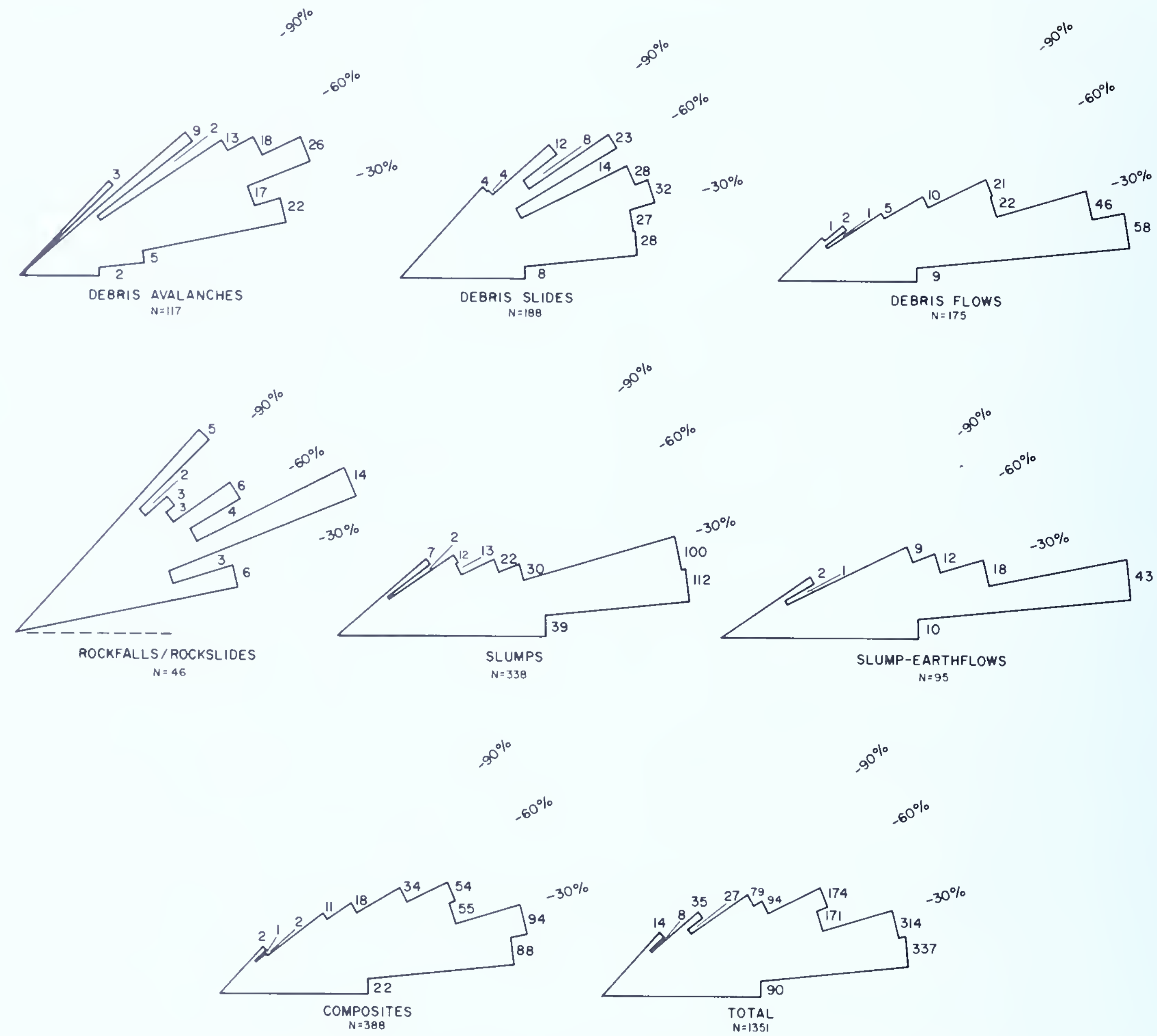

Figure 79. Frequency distribution of landslides by percent slope for each landslide type. The area of each wedge, not its radius, is proportional to the number of slides.

stability of the slope. He suggested that the greater availability of groundwater and the effects of loading by thicker overburden are factors in making the lower portions of a slope less stable. Pomeroy (1982a) suggested that this component might be important in parts of Allegheny and Beaver Counties, where most landslides take place on lower slopes. The lower slopes are commonly sites of thick colluvial deposits, including old landslides.

The direction in which a slope faces (the azimuth or aspect) is a factor that can affect landsliding potential in several ways. Pomeroy (1982a) found more slides on north- and east-facing slopes than on those facing south and west in Washington County, Pa. A number of workers have found preferred orientations in a variety of landslide areas (see Pomeroy, 1982a and 1982b, for Pennsylvania examples). The most commonly suggested nonstructural reason for preferred orientation of landslides is differences in soil-moisture conditions due to differing intensities of exposure to sun. North- and east-facing slopes receive less effective insolation and tend to stay wet longer. Snow cover remains longer for the same reason. Variation in the number and intensity of freeze-thaw cycles might cause a preferred orientation by affecting the development of fracturing on rock faces, or by allowing more rapid development of thicker colluvium. Slope steepness commonly varies with orientation. Asymmetrical valleys having steeper north-facing slopes have been described in a number of areas (Pomeroy, 1982b).

The distribution of surficial deposits can also be affected by slope orientation in ways not related to in-

solation. Coates (1974) described several of these from New York State, including "till shadow hills" formed by southward ice movement, where thick till deposits are found on south-facing slopes and only thin tills on the steeper north-facing slopes. He also suggested that, because of patterns of ice movement and lake damming, fine-grained sediments are more common on north-facing valley sides.

In the Williamsport map area, however, evidence suggests that slope azimuth is not a major factor in determining slope stability. Circular frequency diagrams of slope azimuth for each slide type are shown in Figure 80. Simple statistical tests show that only the distribution of azimuths for debris avalanches departs significantly from a normal circular distribution. Debris avalanches do seem to occur preferentially on north-facing slopes. No preference is apparent for the other slide types, or for the total sample of landslides over the whole quadrangle.

The final topographic feature affecting landslide susceptibility is the configuration or lateral curvature of a slope. Concave slopes have been recognized as sites of likely landslide occurrence in the Appalachian region and elsewhere (Lessing and others, 1976; Pomeroy, 1982a). Topographic hollows, locally termed "coves" or "bowls," tend to concentrate both surface water and groundwater flow and also tend to have thicker accumulations of colluvium. No formal data on slope configuration in the Williamsport area were collected, but the general rule of high correlation between landslides and concave slopes appears valid for the study area.

WATER

Of the factors affecting slope stability, water is probably most often cited as the immediate, or trigger, cause. Water conditions vary more over time than most other factors and are involved in a very high proportion of all landslides. Heavy precipitation is commonly a factor in landsliding, but groundwater conditions and surface-water flow also affect slope stability. Both intense short-period precipitation and extended periods of greater-than-normal rainfall affect landsliding.

Much of the rainfall in the Williamsport area comes in brief but intense showers and thunderstorms. Extreme precipitation events are rare but do occur. The heaviest known rainfall from a single storm in the area was in July 1942 in Potter, Cameron, Elk, and McKean Counties and adjacent parts of New York State. During this storm, more than 30 inches of rain fell in several areas and more than 10 inches fell over an area of approximately 2,000 square miles (Eisenlohr, 1952). Many landslides were observed after this storm, including one along Kettle Creek described as about a mile long and a quarter of a mile wide at the toe. An unusual amount of landslide activity was noted after the heavy rains associated with tropical storm Agnes in June 1972. Rainfall totals for a four-day period during this storm ranged from about 6 to 16 inches in north-central Pennsylvania (Bailey and others, 1975). The effects of major rainfalls are not always immediate. In south-central New York, deep-seated landslides attributed to tropical storm Agnes generally occurred a year or more after the storm (Dwight Sangrey, oral communication, 1984), although the shallow, surficial slides and debris avalanches more typically associated with rainfall usually occur during or soon after a storm. In May 1978, during an intense thunderstorm, a debris avalanche near Torbert, Lycoming County, flowed rapidly down the mountainside and damaged a house in the valley (for more detailed information, see p. 28–30). Many similar debris avalanches are apparently related to rainfall, but few were actually observed in motion.

Rainfall need not come in a single great storm to affect slope stability. Extended periods of wetter than normal weather, or normal seasonal variations in precipitation or snowmelt rates, can lead to elevated groundwater levels, increased spring and seepage activity, and high streamflows. All of these factors can cause increased landsliding.

Groundwater affects landsliding in a number of ways. The shear strength of most soils and some rocks is closely related to their water content. Increasing the water content of a clay-rich soil reduces its strength, allowing it to behave plastically, and eventually, as a fluid. Another factor is that with continued exposure to water, clays and other minerals can undergo chemical changes. These weathering processes generally result in a decrease in strength. Both water content and weathering are partially controlled by the amount of water that can move through the soil or rock. Therefore, the presence of permeable zones and fracture and bedding-plane openings can affect water conditions.

Another way in which groundwater can act to decrease shearing resistance of a slope is through the effects of excess pore pressure. The water pressure in saturated soil or in rock can be increased due to a high water table, loading by overlying material, or other causes. The increased water pressure reduces the effective forces at grain-to-grain contacts, reducing the internal friction and the shear strength of the material.

Groundwater can also affect landsliding by increasing the stresses tending to cause sliding. The difference in weight between saturated soil and drained soil can be enough to trigger movement. Excess pore-water pressure acting behind the head area of an in-

cipient slide increases internal pressure and tends to cause movement, as does the pressure of ice freezing in rock discontinuities and widening the fractures. The weathering and erosional effects of seepage and sapping by groundwater and soil water are also important. Grain-by-grain erosion of sediment by outflow of soil water or groundwater from a slope can cause the development of zones of piping or notching, which gradually undercuts the slope and leads to failure. Seepage erosion along a spring line of discharge points at the intersection of the water table with a slope can be a factor in continual cliff retreat when the seepage resteepens the cliff after each failure (Higgins, 1984).

Surface water also plays a role in landsliding. Infiltration of direct overland runoff of rainfall is probably the principal factor in debris avalanches and other slides associated with heavy rainstorms. Stream erosion can remove buttressing material from the toe of a slope, causing large slides as well as minor riverbank slumping. Hamel (1983) has suggested that most riverbank erosion may be caused by progressive small-scale landsliding rather than by direct removal of undisturbed sediment by flowing water. Many of the slumps and other slides in unconsolidated materials in the Williamsport area can be related to removal of material by stream erosion. Reservoirs and other surface-water impoundments can cause groundwater levels to rise and affect slope stability over large areas. Rapid fluctuations in water levels of reservoirs can trigger landslides due to groundwater drainage after drawdown.

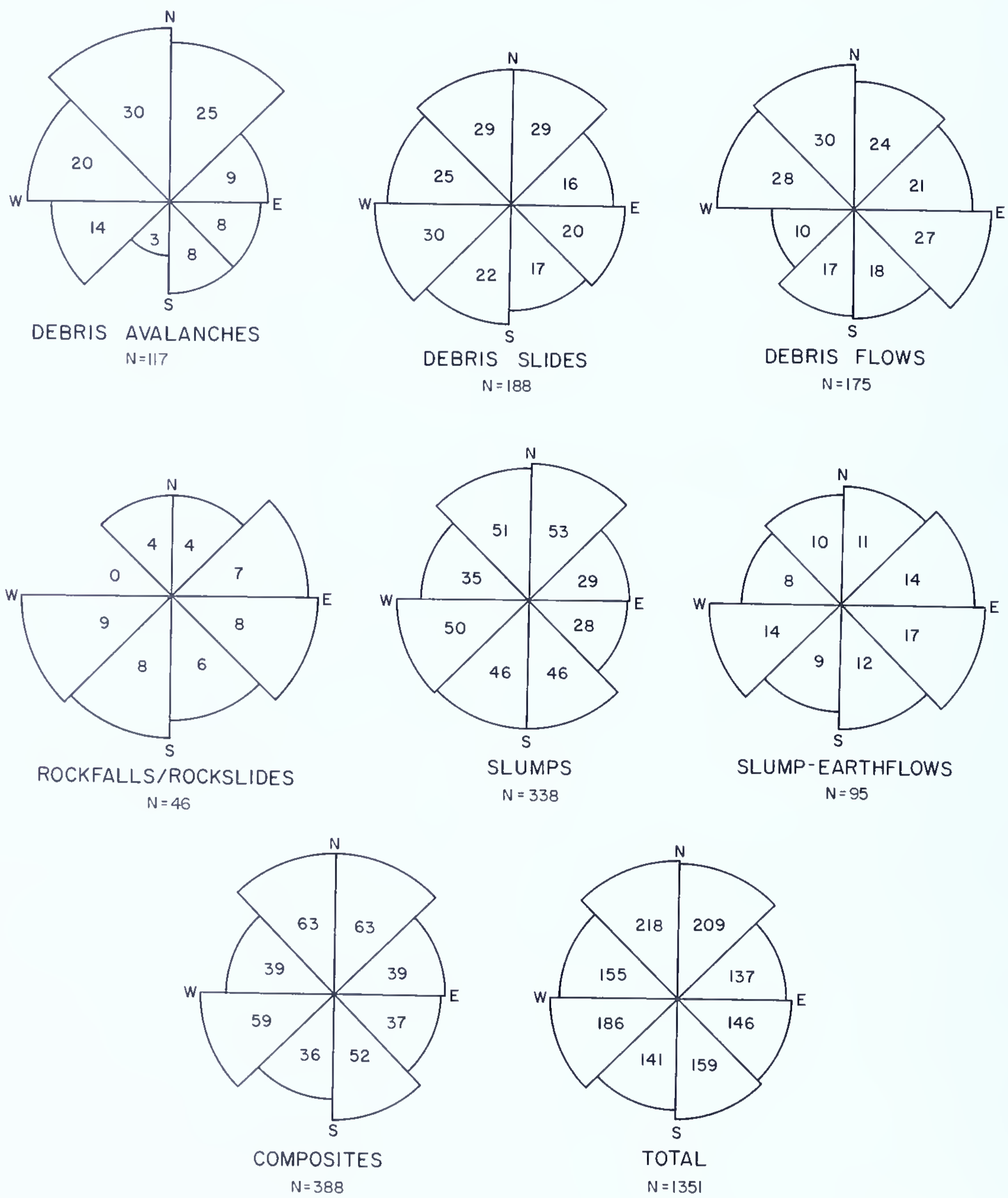

Figure 80. Frequency distribution of landslides by slope azimuth for each landslide type. The area of each segment, not its radius, is proportional to the number of slides.

HUMAN ACTIVITY

The changes that people cause to the land are the fourth major category of landslide factors. Most of these are similar in mechanism to natural factors already discussed but are likely to differ in scale and distribution. Perhaps the most common way that people cause landslides is by changing water conditions. Diversion or blockage of permanent or intermittent drainage paths can change groundwater levels and flow systems. Clearing of forest vegetation normally causes a local rise in water table and changes the rates at which rainfall infiltrates the ground. Irrigation of agricultural areas or lawns is believed to have triggered slides in some areas. Trenches for water, sewer, and other pipes can disrupt normal groundwater flow patterns, and leaking pipes cause many slides, especially in older urban areas. Failure of street drains and other drains can also be a problem.

Excavation for large construction projects is another common way in which people affect landsliding. Removal of material at the toe of a slope for highway or other construction commonly causes failure of the remaining hillside. A very large slump-earthflow occurred in 1975 due to excavation for the Tioga Dam and associated highway relocation (Wilshusen and Wilson, 1981). This slide involved till or colluvium over a layer of glacial-lake clay. Repair costs for the dam abutment site and highway were approximately $3.5 million. Cutting the toe of a slope is one of the most obvious factors in many of the continuing maintenance problems due to slides and rockfalls along roads in the Williamsport area and elsewhere. Placement of the excavated material elsewhere as fill can cause equally serious problems if careful attention to design and construction is not given. The additional weight of fill on a marginally stable site can trigger a failure much larger than the fill area, although failures within fill materials can also cause severe damages. Relatively minor construction activities can have large consequences if they disrupt normal patterns of water movement. Placing clay-rich fill over drainage areas on a hillside, cutting roads across a slope, and diverting drainage from a paved parking lot are examples.

The final major category of man-made landscape changes affecting landslide potential are those related to mining. Strip mining of coal has left significant areas in the Williamsport quadrangle with abandoned highwalls and piles of mine waste. As the rocks weather, the highwalls are increasingly likely sites for rockfalls and rockslides. The spoil piles do not appear to have had extensive landslide problems, but several instances of landslides were observed, and caution is urged in these areas. Subsidence due to underground mining has been described as a cause of landsliding in western Pennsylvania and other areas. The authors are not aware of any slides associated with underground mines in the Williamsport area, but iron ore, clay, and coal have all been mined within the area, and collapse of old mine workings is a potential landslide factor.

A few other miscellaneous factors can relate to landsliding. Earthquakes are well known to have acted as triggers for landslides in many areas, including California, Montana, New Zealand, and the areas around the New Madrid fault zone in Missouri (Keefer, 1984). Although earthquakes have been felt within the Williamsport area, they have been of relatively low intensity, and no correlation with any landsliding is known. Vibrations due to construction activity, weakening of slope materials by progressive soil creep, and actions of tree roots and burrowing animals have been suggested as causes of landslides, but none of these are known to be significant in the Williamsport quadrangle.

LANDSLIDE SUSCEPTIBILITY

Many methods of assessing slope stability and degrees of landslide hazard are available. A review of the subject by Varnes (1984) covered a number of these, ranging from identification of landslide-prone bedrock units through statistical methods based on the distribution and density of old slides and methods based on conventional engineering analysis of specific sites. The appropriateness of various methods depends on factors such as the scale of the final map, the similarity or variability of terrain conditions across the area, the amount and distribution of information on existing landslides, and the availability of supporting information.

The interpretation of landslide susceptibility shown on Plate 1 is based on a synthesis of the results of the partial landslide inventory and published geological mapping. Information on the individual slides discussed under "Occurrence" in the "Landslide Types and Occurrence" section and results of the analysis of the inventory data were used to determine the landslide-related characteristics of various geologic and topographic settings. These were then extended into areas with less-complete inventory information.

Landslide susceptibility varies greatly over the Williamsport quadrangle both in degree and in the type of landsliding that can be expected. Plate 1 is a map of the study area showing susceptibility to landsliding; dots indicate the locations of individual identified slides. Three zones are delineated: (1) a high-susceptibility zone, Zone 1; (2) a moderate-susceptibility zone,

Zone 2; and (3) a low-susceptibility zone, Zone 3. Because of variations in geology and landslide types, each susceptibility zone includes areas representing a number of geologic and topographic factors. The susceptible areas are summarized below by zone, and then discussed in more detail for each section of the 1- by 2-degree area.

HIGH-SUSCEPTIBILITY ZONE (ZONE 1)

Zone 1 designates the areas most highly susceptible to landslide occurrence, the high-susceptibility zone. The first category within this zone includes the areas underlain by glacial-lake clays, which are prone to slumping when disturbed by loading or by erosion at the toe. Landsliding in these areas has caused problems with dam construction and is a continual factor in highway maintenance. The valleys of the Cowanesque and Tioga Rivers (Figure 8) and their tributaries have the largest concentrations of known occurrences, but many rivers in the area were glacially dammed and their valleys may contain glacial-lake clays. Because of the lack of detail in the known distribution of clays and the scale of Plate 1, many small areas without clay deposits are probably included within the high-susceptibility zone.

The second group of areas within the high-susceptibility zone is the steep valley sides in the dissected Deep Valleys and Glaciated High Plateau sections in the western part of the map area, which are underlain mostly by the Huntley Mountain and Catskill Formations. The surface materials are typically thin colluvium and residual soils. Debris slides, debris avalanches, rockslides, and rockfalls are the most common slope-failure types.

Other highly susceptible areas are the steep slopes along the Allegheny Front where the rocks are folded and fractured; the northwest side of Bald Eagle Mountain, which has a thick accumulation of colluvium and possible pre-Wisconsinan glacial deposits on an overdip slope; the glaciated dip slopes of the fold mountains in the southeasternmost portion of the quadrangle; and a few high river banks along meander bends on the Susquehanna River.

MODERATE-SUSCEPTIBILITY ZONE (ZONE 2)

Zone 2 designates areas having moderate susceptibility to landsliding, the moderate-susceptibility zone, and is almost as varied as Zone 1. The moderately sloping portions of the Deep Valleys and Glaciated High Plateau sections near the contact between the Catskill and Huntley Mountain Formations, and the same stratigraphic zone throughout the eastern part of the quadrangle, are less prone to sliding than similar but steeper areas in the west. The folded sandstones and shales near the Allegheny Front provide the setting for rockslides and debris slides, especially where disturbed by excavation for roads and other construction projects. A number of stream valleys in the northeastern part of the quadrangle are not known to contain glacial-lake clays but are included here because of significant occurrences of stream-bank slumps and other landslides. Unreclaimed strip-mine and spoil areas in Pennsylvanian-age rocks are also included in Zone 2.

LOW-SUSCEPTIBILITY ZONE (ZONE 3)

The remainder of the area of the quadrangle has been designated as Zone 3, having generally low susceptibility to landsliding. This zone includes the flat uplands in the plateau areas, the flat bottoms of major stream valleys, gentle and some moderate slopes in the glaciated plateaus, and areas of carbonate rock in the Ridge and Valley province.

MAP USE

The map (Plate 1) is intended to be a general guide to conditions that can be expected in various areas, but it cannot replace detailed site investigations and should be used with caution. Because of the scale, some areas are too small to be shown on the map, whereas others are almost certainly omitted due to error or lack of detailed knowledge of the area. The map should be useful to engineers, planners, and other land use decision makers in identifying areas where special care or further investigation is needed.

The pattern of landslide occurrences shown on Plate 1 indicates that there are more landslides in the western part of the study area than in the east. Several geologic and topographic factors roughly correlate to the variation across the quadrangle. The authors do not have adequate evidence to suggest a single cause but offer several possibilities. The most obvious is that there is generally less relief and most slopes are less steep in the eastern section. A second is that the apparent decrease in landslide activity occurs in the direction of the source area for the Upper Devonian sediments. Lithologic changes related to depositional environment, such as an increase in the sand:shale ratio, could account for the difference. Third, the glacial history of the area may provide the answer because the lower concentration of landslides occurs in those parts of the area most strongly affected by Wisconsinan glaciation. Tills can be expected to be more uniform over a wide area than colluvial deposits derived from the same underlying bedrock types. Proba-

bly a combination of these and possibly other factors provides the explanation.

AREA DESCRIPTIONS

The following descriptions of landslide susceptibility zonation cover blocks of four 7.5-minute quadrangles, beginning in the northwest corner of the map area. Figure 19 is an index map of the 7.5-minute quadrangles in the 1- by 2-degree map area.

Ellisburg, Ulysses, Sweden Valley, and Brookland Quadrangles

The only high-susceptibility area within these quadrangles is the Genesee River valley, which is reported to contain glacial-lake deposits. The moderately susceptible areas are valley side slopes underlain by bedrock of the Catskill and Huntley Mountain Formations. The slopes are mantled with colluvium and some till and include numerous old (late Pleistocene?) debris flows that appear to be stable unless disturbed.

Harrison Valley, Potter Brook, West Pike, and Sabinsville Quadrangles

The highly susceptible areas in these quadrangles include the upper portion of the Cowanesque River basin. Extensive deposits of glacial-lake clay are known in this valley (Willard, 1932; Coates, 1966). The clay is discontinuous but also may occur at depth below other sediments. In the absence of detailed information on clay distribution, the whole valley below the elevation of the highest known clay should be considered highly susceptible. In the southern quadrangles, steep tributary valleys to Pine Creek are prone to debris slides in till and colluvium derived from the Catskill and Huntley Mountain bedrock, and to reactivation of very old debris flows. Glacial-lake clays are known near West Pike (Crowl and Sevon, 1980) and probably occur elsewhere in the valley.

The Zone 2 areas here include the upper valley slopes in the Cowanesque drainage, and the moderately steep slopes above Genesee Forks and the upper tributaries of Phoenix Run, which are underlain by sandstones, siltstones, and shales of the Catskill and Huntley Mountain Formations.

Knoxville, Elkland, Asaph, and Keeneyville Quadrangles

The high-susceptibility zone in the Cowanesque Valley continues east from the adjoining quadrangles. Glacial-lake clays have caused many problems in this area and are also believed to occur in the valley of Crooked Creek. Steep till- and colluvium-mantled slopes in the southern section are similar to those in adjoining quadrangles and comprise the remainder of the high-susceptibility zone in these quadrangles.

The moderate-susceptibility zone includes till- and colluvium-covered slopes on the valley walls above Crooked Creek. The upper reaches of the Crooked Creek valley are probably above the limit of glacial-lake clays, but bank slumping indicates moderate susceptibility to sliding of the material in the valley.

Tioga, Jackson Summit, Crooked Creek, and Mansfield Quadrangles

The valleys of the Cowanesque and Tioga Rivers and their tributaries in these quadrangles are the sites of many landslides involving glacial-lake clays, and make up the Zone 1 portion of the area. Notable occurrences are the very large slide that interrupted construction of the Tioga Dam and associated highway changes (Wilshusen and Wilson, 1981), and the dense concentration of old and recent slumps along North Elk Run southwest of Mansfield (Figures 18 and 54–57). The filling of the Tioga, Hammond, and Cowanesque Reservoirs does not seem to have triggered any major landslide problems.

The construction of U.S. Route 15 led to a number of new slides in thick tills on the upper slopes (Figure 17); these areas are classified as having moderate susceptibility to landsliding.

Millerton, Gillett, Roseville, and Troy Quadrangles

The high-susceptibility zone is made up of areas underlain by glacial-lake deposits in the valleys of Mill, Hammond, and Seeley Creeks. The valleys of Bailey Creek and the unnamed stream at Austinville, and the area near the Catskill-Huntley Mountain contact on the north slope of Armenia Mountain, make up the moderate-susceptibility zone for these quadrangles.

Bentley Creek, Sayre, East Troy, and Ulster Quadrangles

The Zone 1 areas in these quadrangles are glacial-lake clay deposits in north-draining stream valleys and some of the Susquehanna River tributaries, and the very steep slopes along the east bank of the Susquehanna River near Sayre. The valley of Sugar Creek is designated as moderately susceptible to landsliding.

Litchfield, Windham, Towanda, and Rome Quadrangles

The high, steep slopes along meander bends in the Susquehanna Valley, and three small drainages containing glacial-lake clay, comprise the high-susceptibility zone. The moderate-susceptibility zone continues along Sugar Creek from the adjacent quadrangles.

Little Meadows, Friendsville, Le Raysville, and Lawton Quadrangles

No highly susceptible areas occur within these quadrangles. The Wyalusing Creek valley is included in the moderate-susceptibility-zone designation.

Ayers Hill, Cherry Springs, Conrad, and Short Run Quadrangles

The high-susceptibility zone is made up of the steep entrenched valleys underlain by the Catskill and Huntley Mountain Formations. The valleys include Prouty Run, East Fork Sinnemahoning Creek, the upper section of West Branch Pine Creek and its tributaries, and the tributaries to Kettle Creek. Included are ancient (periglacial?) debris flows as well as steep slopes that have thinner colluvium and fractured bedrock and are prone to debris slides and rockslides.

The moderately steep upper slopes of major valleys and upper portions of drainage basins, underlain primarily by the Huntley Mountain Formation, make up Zone 2. The colluvial mantle is generally thicker there than on the steeper slopes. The area includes numerous old debris flows that are slide prone if disturbed.

The low-susceptibility zone is the gently sloping upland areas, largely underlain by Pottsville sandstones.

Galeton, Marshlands, Oleona, and Lee Fire Tower Quadrangles

The high-susceptibility zone in these quadrangles includes the valleys of Pine Creek and its tributaries. Upstream from Galeton, the steep valley sides are prone to debris slides in colluvium derived from the Catskill and Huntley Mountain Formations. Near to and downstream (northeast) from Galeton, the valley was glaciated, and the resulting lake clay, till, and other glacial deposits are prone to slumping and earthflow. In the southern part of the area, the Kettle Creek valley and upper tributaries to Young Womans Creek and Slate Run are included in Zone 1 because of steep colluvial slopes underlain by the Catskill and Huntley Mountain Formations.

The moderate-susceptibility areas include the moderately steep slopes in the southern part of the Galeton quadrangle, which are mostly developed on Catskill sandstones and shales, and the similar area southeast of and parallel to Kettle Creek. The glaciated upper slopes on the Marshlands quadrangle make up the rest of Zone 2 for these quadrangles.

The gently sloping upland areas are generally not susceptible to landsliding.

Tiadaghton, Antrim, Cedar Run, and Morris Quadrangles

The extremely steep slopes of the upper Pine Creek Gorge and the steep to very steep slopes along Cedar Run, Babb Creek, and their tributaries and Pine Creek above the gorge are the Zone 1 portions of these quadrangles. The bedrock is primarily Catskill and includes some of the Lock Haven and Huntley Mountain Formations and Burgoon Sandstone.

Moderate-susceptibility areas are the upland area west of Pine Creek on the Tiadaghton quadrangle; the glaciated upper slopes above Ansonia; and a number of moderately steep narrow zones along the contacts between the Catskill and Huntley Mountain Formations and between the Catskill and Lock Haven Formations, and along the upper reaches of major streams.

The low-susceptibility zone includes upland areas between major streams, and the gently sloping uplands comprising most of the Tiadaghton and Antrim quadrangles.

Cherry Flats, Blossburg, Nauvoo, and Liberty Quadrangles

Small areas of the steep Pine Creek tributary valleys that continue into this area from the west and south are included in Zone 1. The upper part of the Tioga River valley and its glacial-lake clay deposits make up the remainder of the high-susceptibility zone for these quadrangles.

The moderate-susceptibility zone includes the slopes of Maple and Pine Hills along the Catskill-Huntley Mountain formational contact in the north, the similar contact zone south of Nauvoo, the upper reaches of the valleys of Babb Creek and its tributaries, strip-mined areas in the uplands around Blossburg, and the steep slopes of Laurel Hill and more gently sloping area to the north on the Liberty quadrangle.

The remaining areas, which are gently sloping, are placed in Zone 3.

Gleason, Canton, Ralston, and Grover Quadrangles

No high-susceptibility areas occur within these quadrangles.

The moderately susceptible north and east slopes of Armenia Mountain along the Catskill-Huntley Mountain contact continue into these quadrangles from the north. A few small, abandoned strip-mine areas are present on the Gleason quadrangle. The valley floors and lower slopes of the upper reaches of the Tioga River and of Towanda Creek are included in Zone 2. The zone around the contact between the Catskill and Huntley Mountain Formations along Lycoming Creek, Rock Run, and Pleasant Stream and the north slope of the eastward extension of Laurel Hill comprise the remainder of the moderate-susceptibility zone.

Leroy, Powell, Shunk, and Overton Quadrangles

Towanda Creek valley below the West Franklin area is prone to slumping in glacial-lake clays and is included in the high-susceptibility zone.

The upper section of the Towanda Creek valley, the tributary valleys south of Powell, and the north-facing slope above and south of Towanda Creek are classified as having moderate susceptibility. In the southern quadrangles, parts of the valleys of tributaries to Loyalsock Creek are also in Zone 2.

Monroeton, Wyalusing, Dushore, and Colley Quadrangles

The presence of glacial-lake deposits in the Main and South Branches of Towanda Creek is the basis for classifying these areas as highly susceptible. Two small areas of very steep rock slopes on the outside of meander bends of the Susquehanna River in the northeastern part of the study area complete Zone 1.

Zone 2 areas include slopes along the upper part of Loyalsock Creek and the moderately steep slopes of Kellogg and Robwood Mountains south of Monroeton. The upper part of Mehoopany Creek drainage near Colley is also moderately slide prone. All of these areas involve till and colluvium on bedrock of the Catskill and Huntley Mountain Formations.

Laceyville, Auburn Center, Jenningsville, and Meshoppen Quadrangles

These quadrangles have no areas in the high-susceptibility zone.

The Mehoopany Creek drainage area and adjacent areas to the east, south of the Susquehanna River, form the largest part of Zone 2 in these quadrangles. Also included are the Little Mehoopany Creek valley and Meshoppen Creek and the adjacent zone to the west along U.S. Route 6 and the Susquehanna River.

The remainder of the southern quadrangles and nearly all of the northern quadrangles are in Zone 3.

Hammersley Fork, Tamarack, Keating, and Renovo West Quadrangles

A large part of these quadrangles is designated as highly susceptible to landsliding. The Zone 1 areas are the steep slopes above the deeply entrenched streams in the Plateau. The slopes above Kettle Creek, Sinnemahoning Creek, the West Branch Susquehanna River, and their tributaries are especially prone to debris slides, avalanches, and flows in the colluvium developed on the Catskill and Huntley Mountain Formations.

The moderate-susceptibility zone is made up of moderately steep colluvial slopes around and northeast of Tamarack Swamp, and the abandoned strip-mine areas on the plateau tops north of the West Branch Susquehanna River.

The other upland areas, largely underlain by Burgoon and Pottsville sandstones, are designated as the low-susceptibility zone, as are the wide, flat areas in valley bottoms along major streams.

Young Womans Creek, Slate Run, Renovo East, and Glen Union Quadrangles

These quadrangles are similar to those to the north and west. The steep valley sides along Young Womans Creek, the West Branch Susquehanna River, Pine Creek, and their tributaries are highly susceptible to debris sliding.

Small areas of moderately steep upper slopes and upper tributary valleys are in Zone 2, and the plateau tops and small areas of valley bottoms are low-susceptibility zones.

Cammal, English Center, Jersey Mills, and Waterville Quadrangles

The steep slopes along Pine Creek Gorge and Little Pine Creek near the Allegheny Front in the southern part of the Waterville quadrangle form the highly susceptible zone in these quadrangles.

Zone 2 includes the moderately steep uplands in the north and east, small strip-mine areas on the English Center quadrangle, and the less steep slopes near the Allegheny Front. Most of the plateau tops are classified as Zone 3.

White Pine, Trout Run, Salladasburg, and Cogan Station Quadrangles

Most of the designated areas on these quadrangles are continued from adjacent quadrangles. The Zone 1 areas are along the entrenched streams in the Appalachian Plateau and along the southern edge of the Plateau.

The moderate-susceptibility zone includes most of the Plateau uplands and the Allegheny foothills area south of the Allegheny Front (Faill and others, 1977b). The Lycoming Creek valley south of the Front is included here because of bank instabilities in local deposits of glacial sediments.

Bodines, Barbours, Montoursville North, and Huntersville Quadrangles

The high-susceptibility zone is made up of a small part of the steep valley of Lycoming Creek, and the steep slopes along Allegheny Ridge and Cove, Blessing, and Jacoby Mountains. As in most of Zone 1, these areas are underlain primarily by rocks of the Huntley Mountain and Catskill Formations.

The slopes of Bodine Mountain, the Lycoming Creek tributary valleys above Bodines, and the south slope of Burnetts Ridge are in Zone 2, as are the moderate slopes in the Catskill and Huntley Mountain rocks east of Proctor. The area south of Allegheny Ridge is in the Ridge and Valley province, and the rocks are more strongly folded than in the Allegheny Plateau to the north. The rocks of the Catskill and upper Lock Haven Formations in this area are prone to sliding, especially when the toe of dipping beds is disturbed (see Figures 24–27). Isolated areas of Illinoian and early Wisconsinan glacial-lake clays and other surficial deposits are susceptible to sliding in the valleys of Loyalsock Creek and the West Branch Susquehanna River (Wells and Bucek, 1980).

The remaining areas, largely uplands, are designated as the low-susceptibility zone.

Hillsgrove, Eagles Mere, Picture Rocks, and Sonestown Quadrangles

A small eastward extension of Allegheny Ridge is the only area of Zone 1 in these quadrangles.

Zone 2 is made up of the moderate slopes along streams draining the Plateau; the glaciated slopes on Catskill bedrock along and north of Muncy Creek; and the Catskill-Huntley Mountain contact zone along Chestnut Ridge, North Mountain, and Huckleberry Mountain.

The uplands of the Plateau and the remainder of the Muncy Creek lowland are in the low-susceptibility zone.

Laporte, Lopez, Elk Grove, and Red Rock Quadrangles

No areas of the high-susceptibility zone occur in these quadrangles. The valleys and moderately steep slopes along the edge of North Mountain are moderately susceptible to sliding in till and colluvium on the Catskill and Huntley Mountain Formations.

Dutch Mountain, Noxen, Sweet Valley, and Harveys Lake Quadrangles

The moderate-susceptibility zone follows the outcrop belt of the Catskill and Huntley Mountain Formations around North, South, and Bartlett Mountains to the eastern edge of the Williamsport quadrangle and also includes the valley sides along Huntington Creek.

Snow Shoe NW, Snow Shoe NE, Snow Shoe, and Snow Shoe SE Quadrangles

In the northwest part of this area, the steep valleys of the West Branch Susquehanna River and its tributaries are highly susceptible to landsliding. Slides in this zone are primarily debris slides and flows in colluvium from the Huntley Mountain Formation.

Farther to the south, the extensive unreclaimed areas from strip mines in the Pennsylvanian coals are classified as Zone 2. Other areas included in the moderate-susceptibility zone are the moderately steep stream-valley sides in the Plateau, and the area where the Catskill and Rockwell (which grades laterally into the Huntley Mountain Formation to the north) Formations crop out along the edge of the Plateau. Several of the roadcuts for Interstate Route 80 in this area have experienced debris slides and flows.

Howard NW, Farrandsville, Howard, and Beech Creek Quadrangles

The high-susceptibility zone in these quadrangles consists of the steep valley sides of Beech Creek, West Branch Susquehanna River, and Lick Run, where they are underlain by the Huntley Mountain Formation; and the northwest slope of Bald Eagle Mountain, which is mantled with thick colluvium.

The moderate-susceptibility zone includes strip-mined areas in the Plateau, the upper slopes of valleys in the Plateau, the Upper Devonian rocks along the Allegheny Front, and the southeast slope of Bald Eagle Mountain.

The unmined areas of the Plateau top, the valley floor along Bald Eagle Creek, and Nittany Valley are placed in Zone 3.

Lock Haven, Jersey Shore, Mill Hall, and Loganton Quadrangles

Zone 1 in these quadrangles includes the thick colluvium and glacial deposits on the bedrock dip slope

on the north side of Bald Eagle Mountain. The areas where the West Branch Susquehanna River, Chatham Run, and Pine Creek have cut down through the folded and faulted rocks along the Allegheny Front are also highly susceptible to landsliding.

Most of the rest of the area of these quadrangles is moderately susceptible to landsliding. The foothills along the Allegheny Front, the upper valley slopes in the Plateau, and most of the upland areas in the Ridge and Valley province are in Zone 2.

The West Branch Susquehanna River valley, Nittany Valley, Sugar Valley, and the western end of the Nippenose Valley are all placed in the low-susceptibility zone.

Linden, Williamsport, Carroll, and Williamsport SE Quadrangles

The only part of Zone 1 in these quadrangles is the north slope of Bald Eagle Mountain, which has been previously described for the adjacent quadrangles.

Part of the Allegheny foothills in the northwest and the upland areas in the southern portion of this area are classified as moderately susceptible to landsliding. A small area along the northern boundary of the city of Williamsport is included in Zone 2 because of mapped deposits of Illinoian glacial-lake clay (Faill and others, 1977a).

Montoursville South, Muncy, Allenwood, and Milton Quadrangles

The only portion of the high-susceptibility zone in these quadrangles is the north slope of Bald Eagle Mountain, which has thick deposits of colluvium and till.

On the north side of the West Branch Susquehanna River valley, tills and other glacial deposits (Faill, 1979) are prone to sliding if disturbed and are placed in Zone 2. The slopes of North and South White Deer Ridges and Nittany Mountain are also in the moderate-susceptibility zone, as is the east end of White Deer Mountain along the west bank of the Susquehanna River, where steep slopes above the river are prone to rockslides and debris slides.

The remaining area, which makes up most of these quadrangles, is in the low-susceptibility zone.

Hughesville, Lairdsville, Washingtonville, and Millville Quadrangles

This entire area is in the low-susceptibility zone. A few known slides have occurred in the surficial deposits, mostly along stream banks, but no significant concentrations of landslide-susceptibility factors are known.

Benton, Stillwater, Bloomsburg, and Mifflinville Quadrangles

The high-susceptibility zone here consists of the steep slopes of Knob, Huntington, and Lee Mountains. Most instability problems along these slopes are related to heavy rainfall and undercutting of the deposits of stony and boulder colluvium (Inners, 1981).

The slopes above the south bank of the Susquehanna River are partially covered with colluvium and pre-Wisconsinan glacial deposits and are included in Zone 2.

The remainder of these quadrangles is in the low-susceptibility zone. The colluvium and glacial deposits are generally stable, although the slopes may fail if disturbed.

Shickshinny, Nanticoke, Berwick, and Sybertsville Quadrangles

The steep slopes of Shickshinny, Huntington, Lee, Penobscot, and Nescopeck Mountains are highly susceptible to landsliding. A number of landslides in bedrock and glacial sediments are known on the south slope of Shickshinny Mountain (Anderson, 1985).

The moderately steep slopes in the Catskill Formation along the lower slopes of the mountains are included in Zone 2.

The remainder of the area of these quadrangles is in the low-susceptibility zone.

CONCLUSIONS

Landslide suceptibility in the Williamsport 1- by 2-degree map area is best characterized as highly variable across the area. Portions of the area range from very highly susceptible to landsliding to having very low susceptibility, and within susceptibility zones there is a great variety of types of landslides and landslide hazards. A number of factors working in combination determine whether a given slope is stable. These factors include the nature of the bedrock and surficial deposits, topography, water conditions, and disturbance by human activity. Bedrock and surficial geology and slope steepness are the primary factors on which the landslide-susceptibility map is based.

Glacial-lake clays are responsible for the highest densities of landslides. Many of the stream valleys in the north-central part of the quadrangle have a very large proportion of area affected by recent or old slumps. The upper tributaries of the Cowanesque and Tioga River valleys are extreme examples, but much of the glaciated portion of the area is similarly affected.

The next most significant category of landslide-prone areas is the colluvial slopes underlain by the

Catskill and Huntley Mountain Formations. The stratigraphic zone near the contact of these units seems especially strongly associated with landslide problems. The reason for this has not been determined, but it is likely to be related to the occurrence of interbeds of shale and mudstone within coarser grained rocks. The Catskill and Huntley Mountain Formations were deposited in a deltaic environment where there was alternate submergence and exposure of the sediments. In southwestern Pennsylvania, the major landslide-prone rocks are red beds or claystones that formed as ancient soils in a similar deltaic setting. The similarity of environment suggests that paleosols (ancient soil horizons) may be involved in at least some of the Catskill-Huntley Mountain-zone landslides. The Catskill-Huntley Mountain zone is consistently more slide prone across the whole study area than adjacent rock units. In the highly susceptible steep valleys of the dissected Plateau, debris slides and avalanches are most likely to occur in these formations or along the contact between them. Along the Allegheny Front, and in the moderately folded foothills south of the Front, most of the rockslides and debris slides occur in these formations. Even in the glacial tills and on the slopes of the steep fold mountains in the southeast, the Catskill and Huntley Mountain Formations seem to be disproportionately represented in landslide occurrences. In many cases, structure or topographic setting may be a more important instability factor than bedrock, but the consistent association of landsliding with particular bedrock units is a very useful factor for mapping susceptibility.

Along the Allegheny Front and in the steep valleys of the Plateau, there is a potential hazard from debris avalanches, which occur in association with heavy rains. Other major landslide areas are the north slope of Bald Eagle Mountain, where complex deposits of thick colluvium and glacial sediments overlie a bedrock dip slope; and the large, old debris flows in the northwestern part of the map area. Both of these occurrences are believed to be related to the intense weathering and mass-wasting conditions that were prevalent during the Pleistocene in areas near the glacial borders. The colluvium and the more well-defined old slide deposits are likely to be reactivated by unusual water conditions or excavation on the slopes.

The remaining significant landslide settings are thick to moderately thick tills and other glacial deposits, especially where they are disturbed; moderately steep upper slopes in the Plateau; and old strip mines and mine spoil areas.

The rest of the study area is of generally low susceptibility to landsliding, but local conditions can lead to slope instabilities in these areas also.

Land use in the project area is dominantly forest and agricultural, and there are only a few large areas of urban development. For this reason, the effects of landsliding have not had a large impact on human activities, but the hazard and damages from landsliding are of large enough magnitude to warrant attention. The authors are not aware of any deaths or major injuries due to landslides within the Williamsport map area, and damage to houses and other structures is rare. These low damage levels are probably due as much to the low density of urban and residential land use as to the characteristics of landsliding.

The greatest damages due to landsliding are caused to highways and railroads, from both slides coming down onto them from above and loss of support when underlying material slumps or slides away. There was no attempt to collect information on costs over the whole area, but repair figures for individual large highway slides range from $500,000 to $3.5 million. Repair of large slump-flow composite slides in unconsolidated material typically includes removal of part of the failed material and installation of gravel drains to control water-pressure buildup within the slide. Rock armor may be used to prevent earthflow while allowing drainage. The costs of "routine" cleanup of small debris slides and flows, and of continual pavement patching in slump areas, are not easily separated from other highway maintenance costs, but obviously they can represent a significant portion of the totals. Even harder to evaluate are the costs of lost or limited use of agricultural land and the costs of time loss and extra travel due to temporary road closings.

Overall landslide occurrence in the Williamsport area is low, especially in comparison to the Greater Pittsburgh area, San Francisco Bay area, Cincinnati, and other very highly susceptible areas. The locally severe problems such as the glacial-lake clays and other areas of high occurrence illustrate the need to consider landslide hazards in making land use decisions in the area. Current trends of increasing population in north-central Pennsylvania, increasing recreational use of public forest lands, and interest in further exploration of the area's oil and gas resources support the idea that development will continue in the Williamsport 1- by 2-degree area. New roads, pipelines, and waste disposal facilities will be built in the area, and other aspects of development will occur. The consideration of landslide hazards as a factor in making land use decisions can allow the potential damages to be reduced greatly by appropriate mitigating engineering or by avoidance of extremely slide-prone areas.

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GLOSSARY

Alluvium. Unconsolidated sediment deposited by rivers and streams.

Anticline. A fold of rock strata that is convex upward.

Azimuth. Compass direction, measured in degrees, clockwise from north.

Boulder field. An accumulation of boulders or angular blocks in which there is no fine material in the upper part.

Colluvial soil. Soil that has been transported some distance downhill by soil creep, slope wash, landsliding, or similar processes.

Colluvium. A deposit of loose rock fragments and soil, formed by downslope movement.

Conglomerate. Sedimentary rock containing gravel- or pebble-sized grains.

Creep. Imperceptibly slow downslope movement of soil or rock debris.

Crown. The undisturbed material adjacent to the highest parts of the scarp of a landslide.

Debris avalanche. Sudden, very rapid sliding and flow of a mass of soil, rock, and vegetation on a steep slope, generally induced by the presence of water.

Dip. The angle that a planar rock surface makes with the horizontal, measured at right angles to the strike.

Dip slope. A slope of the land surface that conforms to the dip of the underlying rocks.

Fault. A fracture in rock along which movement has occurred.

Glaciofluvial. Deposited by rivers or streams associated with glaciers.

Glaciolacustrine. Deposited in lakes associated with glaciers.

Graben. A downthrown block between two faults.

Head scarp. A steep surface on the undisturbed ground at the highest part of a landslide, formed by movement of the slide material.

Interstitial. Occurring in the spaces between rocks or grains of rock.

Joint. A fracture or crack in rock.

Limestone. Sedimentary rock formed from calcite (calcium carbonate).

Lithology. Composition and texture of rock.

Loam. A soil composed of approximately equal parts of clay, silt, and sand.

Moraine. An accumulation of material deposited or transported by glacial ice.

Notching. Erosion of material at the base of a steep cliff, generally by water, producing an undercut slope.

Periglacial. Referring to areas, conditions, processes, and deposits adjacent to the margin of a glacier.

Permeability. The ability of a material to allow fluid to pass through it.

Piping. Erosion of granular material by percolating water below the surface, resulting in long, narrow conduits, or "pipes," through which more material can be transported. Enlargement of pipes by roof collapse is common.

Planar rockslide. Rockslide where the slip surface is a single plane, commonly a bedding surface.

Pore pressure. The pressure of fluid in the pores of rock or soil that pushes outward against the surrounding grains.

Porosity. The percentage of pore space in the total volume of a material.

Progressive slump failure. A series of slumps, each slump occurring in the head scarp of the previous one, causing upslope growth of the failure.

Residual soil. A soil formed from the consolidated rock on which it is resting.

Riprap. A protective armor of closely placed large rocks, generally to prevent erosion by water.

Scarp. A cliff or steep cut produced by differential movement of adjacent blocks along a slide plane.

Seismic. Pertaining to earthquake or earth vibration.

Shale. Sedimentary rock composed of clay or silt particles, which tends to break in thin layers.

Shear strength. Resistance of a material to deformation by shear stress.

Slope percent. A measure of slope steepness calculated by dividing vertical distance by horizontal distance.

Slump. A landslide in which the slide mass rotates backward into the original slope.

Smectite. A group of clay minerals that tend to swell with the addition of water.

Strike. The compass direction of a horizontal line on a bedding plane, joint, or other surface. It is perpendicular to the dip.

Surface of rupture. The surface or narrow zone along which movement occurs between a landslide mass and the undisturbed rock or soil.

Syncline. A fold of rock strata that is convex downward.

Till. Poorly sorted, unstratified sediment transported and deposited by a glacier.

Toe. The lower, generally curved, margin of the disturbed mass of a landslide; the most distant part of the slide from the point of origin.

Topple. A landslide in which the moving material rotates forward out of the slope.

Varves. Alternating layers of coarse and fine sediment, usually deposited in glacial lakes and representing annual variations in conditions.

Wedge failure. A rockslide where the slip surfaces are two or more intersecting surfaces, commonly joints and a bedding plane.

FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM UNITS (SI)

Multiply inch-pound units	*By*	*To obtain SI units*
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	.3048	meter (m)
mile (mi)	1.6093	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	.02832	cubic meter (m^3)
cubic yard (yd^3)	.765	cubic meter (m^3)
	Flow	
foot per second (ft/s)	.3048	meter per second (m/s)

APPENDIX

LANDSLIDE INVENTORY

Table 5 consists of data for the individual landslides identified in the landslide inventory portion of the project. The locations of these slides are shown on the 7.5-minute quadrangle maps following Table 5. The maps that are included are located on Figure 81. For some of the quadrangles, thorough inspection of aerial photographs was carried out. For other quadrangles, only landslide information obtained from other sources is included. In these cases, there may well be other landslides that are not shown on the maps. In all areas, small slides or slides that occurred significantly before or after the time of the aerial photography have probably been overlooked. The maps do not purport to show all recent or older landslides. Rockfalls are represented on the maps by the letter X.

The information on these maps is intended only to show data from this inventory. The susceptibility zones on Plate 1 are intended to delineate areas where detailed studies of specific areas should precede development plans. Neither these maps nor Plate 1 can take the place of such studies. Many of the features shown on the maps have not been field checked.

The column headings and abbreviations used in Table 5 are as follows:

Quadrangle name and number: Standard 7.5-minute quadrangle name and the number assigned by the Federal Information Processing System. Quadrangles are listed in alphabetical order.

Landslide number: The numbering system begins at 1 for each quadrangle. Revision of data after original numbers were assigned has created gaps in the list; not all numbers are now used.

Slide type: DA, debris avalanche; DS, debris slide; DF, debris flow; S, slump; S-EF, slump-earthflow; RF/RS, rockfall and/or rockslide; A, complex of ancient slide deposits; C, composite landslide or undetermined type.

Age: R, active or recent—slides show a clear, fresh scarp, disturbed vegetation, fresh deposits at the toe, or other evidence of recent movement; O, old—includes all slides with no clear evidence of recent movement (the probable range in age is tens to thousands of years); RA, reactivated old slide; U, unknown.

Length and Width: Maximum dimensions in feet down and across slope, measured on the 1:24,000-scale topographic maps.

Percent slope: Maximum relief divided by length. Maximum relief obtained from contours on the 1:24,000-scale topographic maps. Not determined for some very small slides.

Slope azimuth: Compass direction of a line from the crown of the slide down the maximum inclination to the toe. 000, north; 090, east; 180, south; 270, west.

Bedrock Geology: Symbols used are the same as those on the *Geologic Map of Pennsylvania* (Berg and others, 1980) and in Table 3. IPl, Llewellyn Formation; IPp, Pottsville Formation; Mmc, Mauch Chunk Formation; Mb, Burgoon Sandstone; Mp, Pocono Formation; MDr, Rockwell Formation; MDhm, Huntley Mountain Formation; Dck, Catskill Formation; Dlh, Lock Haven Formation; Dtr, Trimmers Rock Formation; Dbh, Brallier and Harrell Formations; Dh, Hamilton Group; Doo, Onondaga and Old Port Formations; DSkm, Keyser through Mifflintown Formations; DSkc, Keyser through Clinton Formations; Swc, Wills Creek Formation; Sbm, Bloomsburg through Mifflintown Formations; Sc, Clinton Group; St, Tuscarora Formation; Oj, Juniata Formation; Obe, Bald Eagle Formation; Or, Reedsville Formation; Ocn, Coburn through Nealmont Formations.

Surficial Geology: c, colluvium; tc, thick colluvium; bc, boulder colluvium; t, till; lc, glacial-lake clay; g, other glacial deposits; r, rock, thin or no cover; f, fill, mine waste, or other man-made deposits; u, unknown or other.

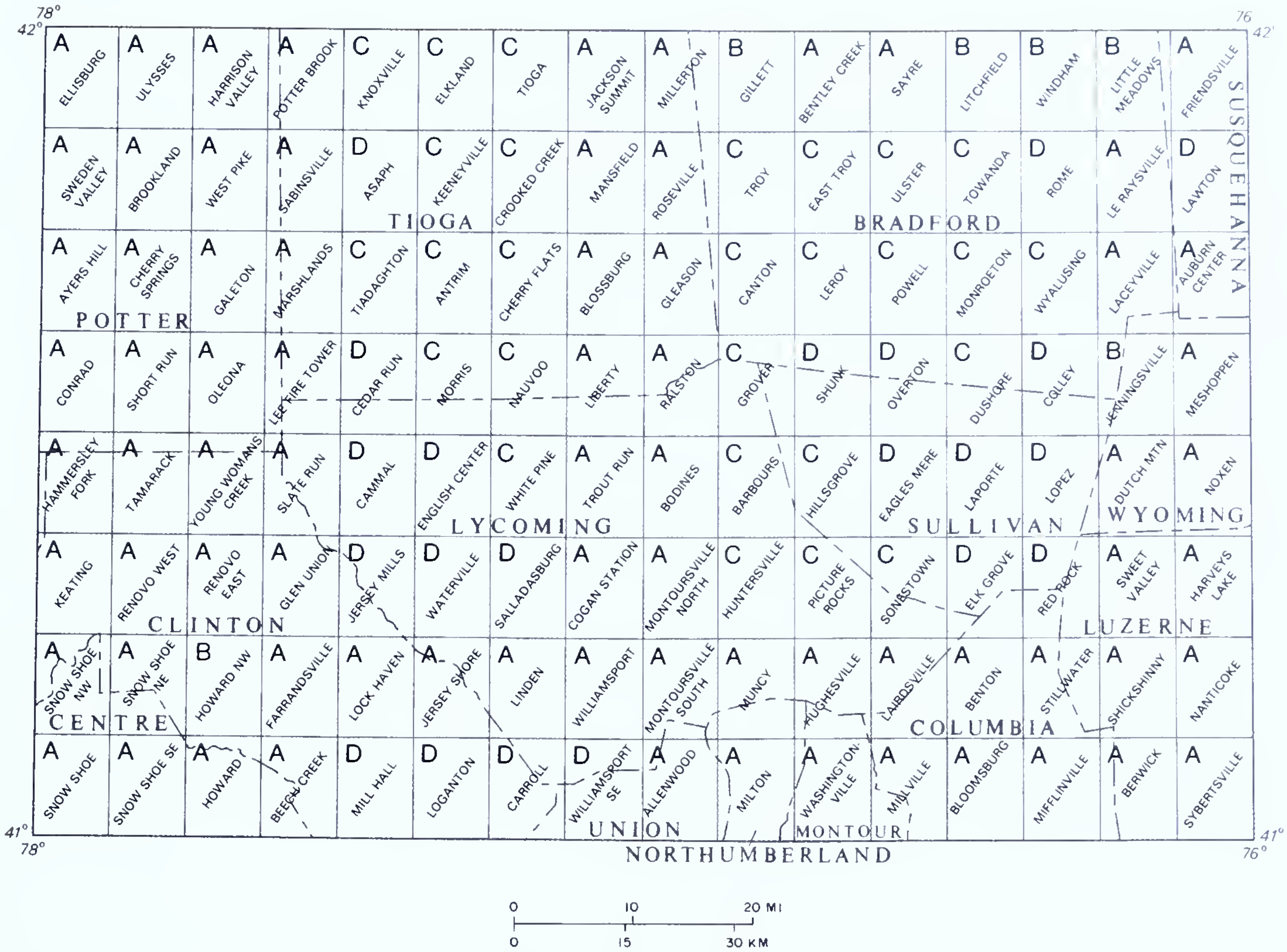

Figure 81. Index map to 7.5-minute quadrangles, indicating the source and type of information in the landslide inventory. A, quadrangle covered by photo inspection, landslides shown on map; B, quadrangle covered by photo inspection, no landslides found; C, quadrangle not fully covered by photo inspection, landslide information from other sources or from photo inspection of adjacent quadrangles; D, quadrangle not covered by photo inspection, no landslides known.

Table 5. Data for Individual Landslides Identified in the Landslide Inventory

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Allenwood	368	1	S	O	100	500	—	180	Sbm	c
		2	DF	O	600	550	27	165	St	bc
		3	DF	O	725	600	26	190	St	bc
		4	DS	R	100	300	40	260	Sbm	u
		5	DS	R	100	200	5	310	Swc	u
		6	RF/RS	R	150	325	60	060	Sc	r
		7	RF/RS	R	200	150	50	057	Sc	r
		8	RF/RS	R	60	100	60	060	Sc	r
Antrim	131	1	DS	R	200	225	25	095	Dck	u
		2	DS	R	150	150	7	250	Dck	u
		3	S	O	250	350	24	130	Dck	c
		4	S	R	150	150	20	030	Dlh	u
		6	S	R	200	300	12.5	290	Dlh	u
Auburn Center	141	2	S	R	125	250	32	105	Dck	t
		3	S	R	150	150	27	025	Dck	t
Ayers Hill	126	2	C	O	800	1,950	20	040	Dck	lc
		4	C	R	150	250	27	005	Dck	u
		11	DF	O	700	350	26	180	Dck	u
		13	C	O	650	600	32	335	MDhm-Dck	u
		16	DF	O	1,250	500	15	290	Dck	u
		18	DF	O	1,250	675	22	315	Dck	u
		19	S	O	525	550	19	345	Dck	u
		20	DS	O	2,300	1,250	25	295	MDhm-Dck	u
		22	DS	O	450	300	44	265	MDhm-Dck	u
		23	C	U	450	100	18	005	Dck	u
Barbours	226	1	DS	R	150	200	40	002	MDhm	c
		2	DS	R	200	250	35	180	MDhm	c
		3	DS	R	100	500	60	150	MDhm	c
		4	DS	R	60	180	67	200	MDhm	c
		5	DS	R	60	80	33	195	MDhm	c
		6	S	R	95	400	11	180	MDhm	c
		7	S	R	60	150	83	185	MDhm	c
		8	S	R	160	350	9	185	MDhm	c
Beech Creek	363	1	C	RA	3,350	5,200	15	330	DSkm-Sc	c
		2	C	O	2,100	1,500	23	345	Sc	c
		3	C	O	2,300	800	30	315	DSkm-Sc	u
		4	C	O	1,775	600	23	330	Sc	u
		5	C	O	950	750	23	330	Sc	u
		6	*See Howard quadrangle (number 362), landslide 21*							
		7	C	O	1,200	1,900	31	150	Or	u
		8	C	O	1,400	2,100	29	140	Or	u
		9	S	O	1,025	1,025	18	150	Ocn	u
		10	C	O	1,750	300	21	320	Or-Ocn	u
Bentley Creek	48	1	C	R	250	500	32	320	Dlh	t
		2	DS	R	250	750	32	340	Dlh	t
		3	C	O	2,000	550	12	053	Dlh	t
		4	C	O	1,550	2,400	12	352	Dlh	t
		5	C	O	1,600	2,750	13	268	Dlh	t
		6	C	O	1,150	2,300	16	261	Dlh	t
Benton	325	1	DA	O	1,120	150	11	310	Dtr	u
Berwick	374	1	DS	R	525	90	50	350	Dtr	bc
		2	S	O	100	175	30	355	Dck	t
		3	RF/RS	R	350	1,400	24	185	Dck	r
Bloomsburg	372	1	DF	U	125	200	60	110	Sbm	c
		2	DS	U	60	90	66	260	Dtr	t
		3	DS	R	115	150	9	160	Sbm	r
		4	DS	R	75	60	13	188	Swc	r
		5	DS	R	75	60	13	185	Swc	r
		6	S	O	100	125	40	140	Dtr	c
		7	DS	O	275	1,000	80	072	Dck	r
		8	DA	O	1,200	225	18	340	Dtr	c
		9	DS	R	75	125	67	328	Dlh	c
Blossburg	133	1	S	R	250	725	24	220	Dck-Dlh	lc
		2	S	R	250	450	28	170	Dlh	lc
		3	S	R	450	950	26	340	Dlh	lc
		4	DF	O	2,250	1,150	16	080	Dck-Dlh	u
		5	C	R	500	150	11	040	Dck	u
		6	S	U	100	375	20	210	Dck	lc
		7	S	U	75	350	20	030	Dck	lc

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Blossburg *(continued)*	133	8	S	U	250	1,500	20	330	Dck	lc
		9	S	U	350	750	20	355	Dck	lc
		10	S	R	400	1,800	23	200	Dck	lc
		11	S	R	225	2,250	30	355	Dck	lc
		12	DF	O	500	200	12	025	Dck	c
		13	DA	O	1,050	125	23	095	Dck	c
		14	DF	O	3,150	1,100	19	285	MDhm-Dck	c
		15	S	U	125	100	8	035	Dck	u
		16	C	O	350	300	20	030	Dck	lc
		17	S	R	250	2,500	24	050	Dck-Dlh	lc
		18	S	R	250	200	20	260	Dlh	lc
		19	S-EF	R	600	175	10	220	Dlh	lc
		20	S	R	150	200	13	225	Dlh	lc
		21	S	R	100	200	10	035	Dlh	lc
		22	S	R	100	200	10	070	Dlh	lc
		23	S	R	400	100	8	005	Dlh	lc
		24	S-EF	R	300	75	7	320	Dck	u
		25	DF	O	3,500	1,200	11	330	MDhm-Dck	c
		26	S-EF	R	300	350	27	265	Dck	u
		27	S-EF	R	300	100	27	240	Dck	u
		28	S	R	75	200	13	140	Dlh	lc
		29	S	R	200	350	5	035	Dlh	lc
		30	DF	O	750	200	17	355	Dck	u
		31	S	U	450	400	4	185	Dck-Dlh	lc
		32	DF	O	3,000	1,250	17	300	MDhm-Dck	u
		33	DF	O	2,200	700	20	085	Mb-MDhm	c
		34	DS	U	500	150	33	300	Mb	u
		35	DS	U	450	100	27	280	Mb	u
		36	S	R	50	150	40	300	IPp	lc
		37	S	R	50	150	40	130	IPp	lc
		38	S	R	150	600	40	320	IPp	lc
		39	S	R	75	200	13	135	IPp	lc
		40	DS	U	225	125	9	040	IPp-Mb	u
		41	DS	U	300	215	13	230	IPp-Mb	u
		42	DF	O	1,250	400	16	330	MDhm	u
		43	S	U	150	150	20	160	MDhm	u
		44	S	U	75	75	13	145	MDhm	u
		45	RF/RS	U	350	150	23	090	MDhm	r
		46	RF/RS	U	100	150	40	095	MDhm	r
		47	S	U	150	200	7	355	MDhm	u
		48	S	U	175	250	14	145	MDhm	u
		49	DS	R	250	300	40	245	MDhm	u
		50	DF	O	1,400	450	13	165	Mb-MDhm	c
		51	DS	R	350	300	11	185	MDhm	u
Bodines	225	1	S-EF	R	150	400	33	200	MDhm-Dck	c
		2	DS	O	150	350	53	000	MDhm	c
		3	DS	O	3,750	700	30	295	MDhm-Dck	c
		4	S-EF	R	200	350	40	170	Dck	t
		5	DA	O	1,750	150	37	250	MDhm-Dck	c
		6	S-EF	R	250	750	24	250	Dck	t
		7	DA	O	1,400	150	37	295	MDhm	c
Brookland	82	1	C	O	1,000	300	18	140	MDhm	t
		2	C	O	800	500	15	155	MDhm	t
		3	S-EF	O	1,800	600	12	152	Dck	t
		4	S-EF	U	350	250	14	050	Dck	u
		5	DF	O	4,500	400	8	140	Dck	c
		6	C	O	700	750	10	105	Dck	u
		7	C	O	700	1,200	20	318	MDhm	u
		8	S	O	800	500	14	155	MDhm	u
		9	S-EF	O	1,000	2,200	30	125	MDhm-Dck	u
		10	DF	O	1,200	300	23	210	MDhm	u
		11	C	O	1,000	2,400	29	057	MDhm	c
		12	DF	O	950	200	33	055	MDhm	bc
		13	DF	O	2,100	650	28	185	MDhm	u
		14	C	O	600	1,500	20	000	Dck	u
		15	C	O	400	1,900	30	140	Dck	u
		16	C	R	275	900	33	340	Dck	c
		17	S-EF	R	525	500	7	175	MDhm	u
		18	C	R	50	100	10	340	Dck	u

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Brookland	82	19	C	R	75	125	13	345	Dck	u
(continued)		20	C	R	100	200	10	150	Dck	u
		21	DF	O	900	700	12	325	Dck	c
		22	DS	R	100	300	40	170	MDhm	c
		23	DS	R	100	650	20	350	Dck	c
Canton	135	1	DS	O	350	950	23	125	Dck	c
		2	C	R	250	200	18	160	Dlh	t
		5	RF/RS	R	125	1,400	160	240	Dck	r
Cherry Flats	132	1	*See Crooked Creek quadrangle (number 87), landslide 4*							
Cherry Springs	127	1	C	O	1,200	850	17	010	Dck	c
		3	C	O	2,100	750	14	035	MDhm-Dck	c
		4	C	O	1,000	500	19	030	MDhm	u
		5	C	O	450	1,100	18	030	Dck	u
		10	DS	O	850	900	34	070	MDhm	c
		11	C	O	950	1,700	29	060	MDhm	c
		12	DA	O	1,500	200	35	270	MDhm	c
		18	C	O	550	1,000	16	050	MDhm-Dck	c
		19	C	R	400	550	35	035	MDhm	u
		20	RF/RS	U	150	1,000	40	170	MDhm	r
		21	RF/RS	U	200	490	30	250	MDhm	r
Cogan Station	272	1	RF/RS	U	150	500	53	040	Dck	r
		2	DA	O	300	75	47	340	Dck	u
		3	DA	O	400	100	56	325	Dck	u
		4	DS	O	850	400	41	200	Dck	u
		5	DA	O	200	150	50	350	Dlh	u
		6	DF	O	650	250	28	275	Dlh	c
		7	DF	O	650	250	29	025	Dlh	c
		8	DS	O	1,100	250	16	225	Dck	c
		9	S	R	75	125	27	310	Dck	u
		10	DS	O	500	100	26	230	Dlh	u
		11	DS	O	500	100	44	022	Dlh	u
		12	DS	O	500	100	49	020	Dlh	u
		13	DS	O	1,400	250	23	300	Dlh	c
		14	DS	R	400	200	45	230	Dlh	u
		15	DS	O	1,250	150	27	195	Dlh	u
		16	S	R	50	75	20	350	Dck	g
		17	S-EF	R	250	200	8	355	Dck	g
		18	S	R	50	200	40	270	Dck	u
		19	DS	O	475	200	31	140	Dck-Dlh	c
		20	S-EF	O	200	450	15	050	Dlh	u
		21	S	U	150	175	19	050	Dlh	c
		22	S	O	750	350	29	045	Dlh	c
		23	RF/RS	R	150	50	67	260	Dlh	r
		24	RF/RS	R	140	65	79	260	Dlh	r
		25	RF/RS	R	140	125	79	260	Dlh	r
		26	RF/RS	R	120	100	92	240	Dlh-Dbh	r
		27	DF	O	600	350	28	160	Dlh	c
		28	S	R	300	600	27	230	MDhm-Dck	t
		29	*See Trout Run quadrangle (number 224), landslide 30*							
Conrad	171	1	DA	U	1,250	250	37	050	MDhm-Dck	c
		3	DF	O	1,500	400	35	305	MDhm-Dck	c
		4	DA	R	1,100	350	41	270	MDhm	c
		5	C	O	1,200	750	20	250	Pp-MDhm	u
		7	DA	O	1,500	150	33	310	MDhm-Dck	c
		8	DF	O	1,750	400	35	290	MDhm-Dck	c
		9	C	O	850	750	24	280	MDhm	u
		10	S	O	150	450	30	275	MDhm	c
		11	S	O	200	450	30	285	MDhm	c
		12	DF	RA	2,500	1,100	27	090	MDhm-Dck	c
		14	C	O	700	1,000	33	250	Dck	u
		19	DF	O	1,900	500	34	150	MDhm-Dck	u
		20	C	R	350	500	34	330	Dck	u
		21	DA	U	1,250	400	42	358	MDhm-Dck	c
		23	S-EF	U	900	550	33	150	Dck	u
		24	S-EF	U	700	350	37	145	Dck	u
		25	DF	O	1,650	600	29	315	Dck	c
		26	DA	O	950	250	38	315	MDhm-Dck	c
		27	DA	U	1,000	200	37	135	Dck	c
		29	DA	U	1,000	200	30	325	Dck	c

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Conrad *(continued)*	171	30	DA	U	1,050	400	24	030	Dck	c
		31	C	O	1,350	550	18	080	MDhm-Dck	u
		32	C	O	1,300	4,100	28	120	Dck	c
		33	C	O	700	1,200	19	025	MDhm	c
		34	DA	O	750	100	37	155	MDhm-Dck	c
		35	DA	O	750	100	53	335	MDhm-Dck	c
		37	DF	U	1,000	300	30	355	Dck	u
		39	C	O	500	650	31	035	Dck	c
Crooked Creek	87	1	S-EF	O	750	500	11	090	Dlh	u
		2	S	R	125	450	16	015	Dlh	lc
		3	S	R	100	400	30	350	Dlh	lc
		4	DF	O	2,025	500	22	335	Dlh	c
		5	S	R	150	250	20	335	Dlh	lc
		6	S	R	100	250	20	310	Dlh	lc
		7	S	R	250	300	14	000	Dlh	lc
		8	S	R	250	500	16	000	Dlh	lc
Dushore	183	1	DS	R	225	650	20	110	Dck	g
Dutch Mountain	231	1	DA	O	1,880	190	30	238	Dck	bc
		2	S	O	700	1,000	26	238	Dck	t
East Troy	91	1	S	R	100	850	40	230	Dlh	t
		2	S	O	300	900	10	345	Dlh	u
		3	S	O	1,150	1,000	16	355	Dlh	u
Elkland	43	1	S	R	200	250	15	340	Dlh	g
		2	C	R	300	400	15	030	Dlh	g
		3	C	R	200	650	3	015	Dlh	g
		4	C	U	250	400	26	210	Dlh	g
		5	C	R	450	2,600	22	320	Dlh	u
Ellisburg	38	1	DF	O	1,500	800	17	334	Dck	c
		2	C	O	900	1,900	19	175	Dck	c
		3	DF	U	2,550	600	12	163	Dck	c
		4	DF	U	3,150	900	12	310	MDhm	c
		5	C	O	600	2,500	22	330	Dck	t
		6	DF	U	1,000	100	24	343	Dck	bc
		7	C	U	300	75	15	358	Dck	u
		8	S-EF	U	500	300	22	040	Dck	u
		9	C	O	1,400	2,100	10	063	Dck	c
		10	DF	R	400	300	18	024	Dck	u
		11	DF	O	1,900	300	11	100	Dck	c
		12	DF	O	3,000	800	7	050	Dck	c
		13	DF	O	1,550	800	10	280	Dck	c
		14	C	O	725	750	22	005	Dck	u
		15	DF	O	1,500	500	13	325	Dck	c
		16	C	O	1,000	2,300	24	110	Dck	c
		17	C	O	1,300	950	7	240	Dck	c
Farrandsville	316	1	DS	O	975	225	47	353	Mb-MDhm	u
		2	C	O	450	1,000	44	338	MDhm	u
		3	C	R	50	200	10	040	MDhm	c
		4	DF	O	1,050	125	43	015	Mb-MDhm	c
		5	DF	O	900	165	53	011	Mb-MDhm	c
		6	RF/RS	R	175	600	49	035	MDhm	r
		7	DS	R	125	350	57	170	MDhm	u
		8	C	R	125	175	50	260	MDhm	u
		9	C	R	150	150	73	270	MDhm	u
		10	C	R	150	300	70	270	MDhm	u
		11	DS	R	550	75	44	255	MDhm	u
		12	RF/RS	O	250	600	24	060	MDhm	r
		13	DS	O	1,150	350	60	065	MDhm	c
		14	DS	RA	200	325	73	065	MDhm	u
		15	DS	R	200	75	95	065	MDhm	u
		16	DS	R	150	100	93	065	MDhm	u
		17	DS	R	175	50	86	070	MDhm	u
		18	DF	O	1,125	375	29	005	Mb-MDhm	c
		19	RF/RS	R	100	100	55	160	Mb	r
		20	RF/RS	R	150	225	93	200	MDhm	r
		21	DS	U	150	200	67	340	MDhm	u
		22	RF/RS	R	150	100	73	350	Mb	r
		23	RF/RS	R	175	100	63	350	Mb	r
		24	RF/RS	R	225	50	60	355	Mb-MDhm	r

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Farrandsville	316	25	S-EF	O	525	225	10	020	Dck	u
(continued)		26	C	O	1,700	2,125	18	128	MDhm-Dck	u
Friendsville	53	1	S	O	350	950	23	040	Dlh	t
		2	S	O	490	570	23	210	Dlh	t
		3	S	O	490	400	18	185	Dlh	t
		4	S	O	325	500	22	105	Dlh	t
Galeton	128	1	C	U	75	550	20	250	Dck	u
		2	S-EF	U	675	1,000	21	350	Dck	u
		3	S	U	125	225	16	340	Dck	u
		4	S	U	150	300	7	010	MDhm	u
		5	C	U	75	1,000	60	140	Dck	u
		6	S	U	85	225	10	200	MDhm	u
		7	C	R	100	150	50	225	MDhm	u
		8	DS	R	100	750	30	220	MDhm	u
		9	S	R	350	125	17	210	MDhm	u
		10	S	R	200	500	25	210	MDhm-Dck	u
		11	DA	O	550	100	40	170	MDhm	u
		12	DA	O	850	100	41	179	MDhm	u
		13	C	R	75	200	20	330	Dck	u
		14	C	U	85	450	47	170	Dck	u
		15	C	R	300	575	27	275	Dck	u
		16	S-EF	O	325	425	28	280	Dck	c
		17	DF	O	1,500	100	34	278	MDhm-Dck	u
		18	C	R	300	450	47	265	Dck	u
		19	C	U	50	750	40	270	Dck	u
		20	S-EF	O	625	3,625	33	268	Dck	c
		21	C	U	85	225	53	110	Dck	u
		22	C	R	185	400	24	120	Dck	u
		23	S	U	225	225	13	290	Dck	u
		24	C	R	175	575	23	300	Dlh	u
		25	S	R	65	150	15	190	Dck	u
		26	C	U	350	300	19	255	Dck	u
		27	C	R	50	50	15	254	Dck	u
		28	C	U	550	800	20	010	Dck	u
		29	S	R	275	200	15	100	Dck	u
		30	C	O	200	1,000	30	070	Dck-Dlh	u
		31			*See Marshlands quadrangle (number 129), landslide 2*					
		32			*See Marshlands quadrangle (number 129), landslide 3*					
Gleason	134	1	S	R	200	250	13	260	Dck	t
Glen Union	268	1	DS	O	1,450	250	43	278	MDhm-Dck	u
		2	C	O	1,000	50	50	340	MDhm	u
		3	C	R	900	100	56	335	MDhm	u
		4	C	R	750	300	51	340	MDhm	u
		5	C	O	1,300	250	48	010	MDhm	u
		6	C	R	200	200	23	130	MDhm	u
		7	DF	O	800	500	90	085	MDhm	bc
		8	DF	O	700	240	53	310	MDhm	u
		9	C	U	1,250	300	21	355	MDhm	c
		10	S-EF	O	1,400	500	41	330	Mb-MDhm	u
		11	C	O	500	150	74	290	MDhm	u
Grover	180	1	DS	O	200	500	20	300	MDhm	c
Hammersley Fork	217	1	DF	O	1,200	550	23	275	MDhm	c
		2	DF	O	1,000	450	29	280	MDhm	c
		3	DF	O	1,500	350	15	020	MDhm	c
		4	C	O	1,750	400	19	340	MDhm	u
		5	DF	O	1,200	450	32	022	MDhm	c
		6	C	U	350	250	23	050	MDhm	u
		7	C	O	1,900	2,500	9	290	MDhm	u
		8	DA	O	750	200	43	100	MDhm	u
		9	DA	O	1,750	400	22	240	IPp-MDhm	u
		10	DF	O	1,400	500	36	050	MDhm	c
		11	DA	O	1,250	300	40	055	MDhm	u
		12	DF	O	2,250	850	34	185	MDhm	c
		13	DF	O	1,200	900	34	095	MDhm	c
		14	DF	O	2,250	1,150	32	015	MDhm	c
		15	C	O	1,750	1,450	50	025	MDhm	u
		16	DF	O	2,000	750	45	080	MDhm-Dck	c
		17	DF	O	2,450	500	38	105	MDhm-Dck	c
		18	DS	O	1,500	550	40	310	MDhm	u

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Hammersley Fork	217	19	C	O	1,750	750	35	310	MDhm	u
(continued)		20	DA	R	300	200	33	025	MDhm	u
		21	DA	U	2,150	250	21	330	MDhm	u
		22	C	O	1,750	950	26	130	MDhm	u
		23	C	R	350	350	54	000	MDhm	u
		24	C	O	1,500	750	43	030	MDhm	u
		25	C	O	1,200	1,750	42	095	MDhm	u
		26	C	O	1,150	950	52	100	MDhm	u
		27	C	R	300	750	60	010	MDhm	u
		28	C	O	1,350	900	44	060	MDhm	u
		29	C	O	1,425	600	45	010	MDhm	u
		30	C	O	1,150	325	59	050	MDhm	u
		31	C	R	500	400	44	060	Dck	u
		32	DF	O	1,725	650	42	204	MDhm	c
		33	C	O	1,100	550	49	225	MDhm	u
		34	C	O	1,050	300	52	235	MDhm	u
		35	C	O	2,300	900	35	140	MDhm-Dck	c
		36	C	O	3,500	1,600	14	115	Dck	u
		37	RF/RS	R	400	1,650	45	080	MDhm	r
		38	RF/RS	R	400	800	44	100	MDhm	r
		39	DA	O	2,075	275	25	035	MDhm-Dck	u
		40	DA	U	1,000	275	40	230	MDhm-Dck	c
		41	DA	U	850	300	43	005	Dck	u
		42	C	O	1,000	1,525	31	300	MDhm	c
		43	C	O	1,525	1,500	25	170	MDhm-Dck	c
		44	DA	O	1,700	500	24	017	Dck	u
		45	DA	O	1,450	200	23	007	Dck	u
		46	DA	O	1,350	150	22	045	Dck	u
		47	DA	O	1,700	400	24	009	Dck	u
		48	C	O	1,350	1,400	18	137	MDhm-Dck	c
		49	C	O	1,750	575	14	250	MDhm-Dck	c
		50	DF	O	2,750	1,200	27	118	MDhm-Dck	c
		51	C	O	1,500	425	29	024	Dck	u
		52	C	R	375	425	53	080	Dck	u
		53	C	O	2,150	2,000	30	040	Dck	c
		54	C	O	875	1,350	32	030	Dck	u
		55	C	O	1,075	350	55	005	Dck-Dlh	c
		56	C	O	3,300	2,100	22	220	Dck-Dlh	u
		57	C	O	325	1,600	52	040	Dlh	c
		58	C	O	1,025	825	24	025	Dck	u
		59	C	R	150	125	68	070	Dck	u
		60	S	R	375	550	53	080	Dck	u
		61	C	R	150	150	53	090	Dck	u
		62	DF	O	900	300	30	220	Dck	c
Harrison Valley	40	1	S-EF	R	300	700	17	085	Dck-Dlh	u
		2	S-EF	U	850	1,250	15	225	Dck-Dlh	u
		3	C	O	2,200	1,350	10	230	Dck-Dlh	u
		4	S	U	675	900	21	205	Dlh	c
		5	S-EF	O	2,300	1,500	14	215	Dck-Dlh	u
		6	C	O	925	625	17	220	Dlh	u
		7	S-EF	RA	900	2,150	12	065	Dlh	u
		8	S-EF	O	1,325	1,225	20	050	Dck-Dlh	u
		9	S-EF	O	2,075	1,100	17	045	Dck-Dlh	u
		10	S-EF	O	1,975	925	14	025	Dlh	u
		11	S-EF	R	700	150	11	240	Dlh	u
		12	S-EF	R	400	350	10	195	Dlh	u
		13	C	O	925	760	16	055	Dlh	u
		14	C	O	675	600	18	060	Dlh	u
		15	S-EF	U	450	125	13	100	Dlh	u
		16	S-EF	O	2,950	975	12	060	Dlh	c
		17	S	R	300	375	7	200	Dlh	u
		18	C	RA	2,200	700	13	085	Dck-Dlh	c
		19	DF	O	2,800	1,000	13	160	Dck	c
		20	DF	O	2,450	1,075	13	165	Dck	u
		21	C	O	1,150	1,000	17	080	Dlh	c
		22	S	R	200	400	20	010	Dlh	lc
		23	S	R	175	350	17	350	Dlh	lc
		24	S	R	175	275	11	050	Dlh	lc
		25	S	R	175	300	17	040	Dlh	lc

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Harrison Valley *(continued)*	40	26	S	R	325	850	18	045	Dlh	lc
		27	DF	O	1,675	725	13	103	MDhm	u
		28	S	O	925	550	25	140	MDhm	u
		29	S	O	450	325	26	220	MDhm	u
		30	C	O	350	100	17	240	MDhm	u
		31	S	R	300	250	23	170	Dck	u
		32	C	O	425	400	28	263	MDhm	u
		33	S	U	200	550	18	130	Dck	lc
Harveys Lake	280	1	S	O	1,250	2,750	18	288	Dck	t
		2	S	O	620	1,000	5	175	Dck	t
		3	DA	R	700	150	20	292	Dck	c
		4	DS	R	90	50	22	022	Dck	t
		5	DS	R	140	75	18	020	Dck	t
Hillsgrove	227	1	DS	R	300	80	37	250	MDhm	t
Howard	362	1	C	O	900	1,500	19	220	Mb-MDhm	c
		2	DF	O	1,440	650	27	015	Mb-MDhm	c
		3	DF	O	800	300	35	347	Mb-MDhm	c
		4	S	O	200	250	25	312	MDhm	u
		5	S-EF	U	400	350	38	020	MDhm	u
		6	C	RA	200	620	45	325	MDhm	u
		7	S-EF	U	580	550	34	310	MDhm	u
		8	DS	R	500	175	74	240	MDhm-Dck	u
		9	DS	R	200	150	60	243	MDhm-Dck	u
		10	RF/RS	R	100	450	50	215	Dck	r
		11	RF/RS	R	150	2,200	47	045	MDhm-Dck	r
		12	DS	O	1,460	250	53	043	MDhm	u
		13	DF	O	1,550	800	21	335	Mb	c
		14	S	O	350	1,120	34	332	Dck	u
		15	DF	O	1,000	350	27	265	Dlh	c
		16	C	O	940	340	23	265	Dlh	u
		17	C	R	440	350	45	005	Dlh	u
		21	C	O	1,850	3,000	17	310	Sc	c
Hughesville	323	1	DS	O	300	180	40	288	Dtr	u
		2	DS	O	650	180	12	270	Dh	c
		3	DF	U	100	150	30	190	Dtr	c
		4	DS	U	140	175	50	244	Dtr	u
Huntersville	274	1	RF/RS	R	200	375	40	325	Dck	r
		2	S	R	100	115	30	350	Dck	bc
		3	RF/RS	R	310	600	32	010	Dck	c
		4	S	R	100	200	20	140	Dck	bc
		5	C	R	100	250	60	145	Dck	u
Jackson Summit	45	1	S	R	450	1,500	18	160	Dlh	lc
		2	C	O	1,400	2,750	20	090	Dlh	g
		3	S	U	220	500	36	220	Dlh	u
		4	S	O	1,100	2,000	21	030	Dlh	lc
		5	S	R	100	200	20	270	Dlh	u
		6	DF	O	2,300	750	16	335	Dlh	g
		7	DF	RA	1,800	850	29	180	Dlh	c
		8	S	R	200	450	15	350	Dlh	u
		9	DF	O	2,500	500	8	245	Dck	c
		10	S	O	700	750	23	120	Dck	g
		11	S	R	100	400	5	005	Dck	u
		12	S	R	125	350	8	355	Dck	u
		13	S-EF	O	450	500	27	095	MDhm	u
		14	S	R	75	250	13	270	MDhm	u
		15	S	R	100	250	30	275	MDhm	u
		16	DF	O	2,750	750	15	155	MDhm	c
		17	DF	O	2,500	750	15	160	MDhm	c
Jersey Shore	318	1	DA	R	1,250	125	48	235	MDhm-Dck	u
		2	C	R	200	250	25	050	Dck	u
		3	S	R	75	100	53	090	Dck	r
		4	C	R	100	100	45	060	Dck	u
		5	S	O	1,900	1,250	38	230	MDhm-Dck	u
		6	C	R	150	750	20	330	Sc	c
		7	DF	O	2,200	800	21	320	Sc, St	u
		8	C	O	1,700	700	41	340	St	c
		9	S	U	150	300	13	150	Doo	u
		10	S	U	100	250	60	160	Dlh	u
		11	C	R	200	500	40	80	Or	u

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Keating	265	1	C	O	1,100	1,075	17	025	MDhm	u
		2	C	O	900	725	14	003	Dck	u
		3	C	O	2,550	950	6	210	MDhm-Dck	u
		4	C	O	900	925	24	200	MDhm-Dck	u
		5	DF	O	1,675	1,775	15	224	MDhm-Dck	c
		6	DA	R	1,050	225	34	334	MDhm-Dck	u
		7	DA	O	2,350	725	29	000	MDhm-Dck	u
		8	DF	O	1,300	525	24	355	MDhm-Dck	c
		9	DF	U	1,500	375	29	324	MDhm-Dck	c
		10	DF	O	1,475	1,550	26	170	MDhm-Dck	c
		11	DA	U	900	150	67	020	Dck	c
		12	DA	U	900	100	69	010	Dck	c
		13	DA	U	1,150	200	59	020	Dck	c
		14	DA	U	900	100	49	240	Dck	c
		15	DA	U	1,050	200	67	285	Dck	c
		16	C	R	75	600	107	190	MDhm	u
		17	C	R	450	300	36	230	MDhm	u
		18	DA	U	850	125	80	250	MDhm	u
		19	DA	U	650	100	68	250	MDhm	u
		20	RF/RS	U	150	550	40	265	MDhm	r
		21	DA	U	925	200	45	028	Mb-MDhm	u
		22	DF	U	425	175	26	062	Mb	c
		23	C	U	1,200	650	25	230	Mb-MDhm	u
		24	DA	O	1,300	200	43	065	Mb-MDhm	c
		25	DS	R	200	150	50	135	MDhm	u
		26	DS	R	200	150	70	140	MDhm	u
		27	DS	R	200	50	90	170	MDhm	u
		28	DS	R	200	50	90	180	MDhm	u
		29	C	O	1,075	1,000	30	030	MDhm	u
		30	C	O	1,150	2,500	30	030	Mb-MDhm	u
		31	DS	R	100	400	60	182	MDhm	c
Keeneyville	86	1	DS	U	50	100	30	060	MDhm-Dck	u
		2	DS	U	75	75	33	065	MDhm-Dck	u
		3	DS	U	50	125	10	040	Dck	u
		4	DS	U	50	50	35	050	Dck	u
		5	DS	U	75	150	27	040	Dck	u
		6	DS	U	75	125	25	050	Dck	u
		7	S	U	125	400	16	050	Dck	u
		8	DS	U	150	750	60	015	Dlh	u
		9	S	R	250	250	16	092	Dck	t
Knoxville	42	1	S	R	90	280	22	023	Dlh	lc
		2	S	O	800	650	15	085	Dck	t
		3	S	O	850	2,300	18	225	Dlh	t
		4	S	O	750	2,000	24	060	Dck	lc
		5	S	O	600	2,400	20	210	Dck	lc
		6	S	R	550	1,375	24	250	Dck-Dlh	t
		7	S	R	435	1,600	14	020	Dlh	g
		8	S	R	350	1,100	27	110	Dck	lc
		9	S	R	300	1,100	32	250	Dck	lc
		10	C	R	300	825	42	300	Dlh	g
		11	C	R	210	800	17	320	Dlh	g
		12	S	R	300	650	22	350	Dck-Dlh	g
		13	S	R	250	550	16	065	Dck-Dlh	g
		14	S	R	275	1,250	16	090	Dlh	g
		15		*See Potter Brook quadrangle (number 41), landslide 9*								
		16		*See Potter Brook quadrangle (number 41), landslide 19*								
		17		*See Potter Brook quadrangle (number 41), landslide 20*								
Laceyville	140	1	S	R	400	200	10	095	Dck	t
		2	DS	R	200	250	40	180	Dck	c
		3	S	R	100	350	80	270	Dck	t
		4	S	R	125	300	64	245	Dck	t
Lairdsville	724	1	S	R	180	100	22	180	Dtr	c
		2	S-EF	R	350	400	51	112	Dck	c
		3	DF	R	60	425	58	220	Dtr	c
		4	DS	R	650	140	23	198	Dtr	bc
		5	S	R	90	100	22	240	Dtr	c
		6	DF	R	135	400	15	272	Dtr	c
		7	DA	R	720	175	14	208	Dck	c

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Lawton	96	1	S	O	200	400	10	060	Dck	t
		2	C	R	200	400	30	210	Dck	t
		3	DS	R	100	850	20	130	Dck	t
		4	S	O	200	800	30	320	Dck-Dlh	t
		5	S	R	100	200	20	270	Dlh	t
Lee Fire Tower	174	1	C	U	375	200	51	250	MDhm	c
		2	DA	O	700	200	33	317	MDhm	c
		3	DA	O	800	150	51	133	MDhm	c
		4	DA	O	1,200	225	42	310	MDhm	c
		5	DA	O	1,175	250	34	000	MDhm	c
		6	DS	U	500	250	56	004	MDhm-Dck	c
		7	DA	U	425	175	31	005	Dck	c
		8	C	R	200	150	65	220	Dck	c
		9	DF	O	975	325	32	110	Dck	c
		10	C	O	1,225	600	25	308	MDhm-Dck	c
		11	C	O	675	800	19	045	MDhm	c
		12	DS	O	400	125	65	335	MDhm-Dck	c
		13	DS	O	375	200	61	333	MDhm-Dck	c
		14	DS	O	1,125	200	54	330	MDhm-Dck	c
		15	DS	O	950	150	44	010	MDhm-Dck	c
		16	DS	O	1,150	200	61	013	MDhm-Dck	c
		17	DS	O	325	125	62	010	MDhm-Dck	c
		18	S	R	125	250	8	055	Dck	c
		19	C	U	1,100	775	72	257	Mb-MDhm	c
		20	C	R	250	100	24	022	MDhm-Dck	c
		21	C	O	250	225	56	021	MDhm	c
		22	C	O	500	175	58	000	MDhm	c
		23	DF	O	900	175	54	025	MDhm-Dck	c
		24	C	U	225	175	62	005	MDhm	c
		25	DF	O	1,100	150	56	265	MDhm-Dck	c
		26	C	O	575	350	33	295	MDhm	c
Le Raysville	95	1	S	R	100	600	40	000	Dck	t
		2	S	R	100	300	30	330	Dck	t
		3	S	R	100	200	30	330	Dck	t
Leroy	136	1	S-EF	R	700	3,000	19	090	Dlh	c
		2	S	R	200	800	40	250	Dlh	c
		3	S	R	100	400	25	005	Dlh	t
		4	S-EF	R	650	2,600	19	060	Dlh	g
		5	S	RA	400	500	15	250	Dlh	t
		6	DS	O	900	900	16	260	Dlh	t
Liberty	178	1	S-EF	R	500	300	13	220	Dlh	u
		2	DF	O	1,450	700	13	270	Dlh	c
		3	C	O	450	300	13	320	Dlh	u
		4	S	R	150	200	13	200	Dck	u
		5	S	R	100	250	10	050	Dck	u
		6	DS	U	150	175	100	140	Dck	u
		7	C	R	250	100	32	088	Dck	u
		8	RF/RS	U	50	250	40	130	Dck	r
		9	S-EF	R	600	300	8	040	Dck	u
		10	S-EF	U	1,450	450	6	235	Dlh	u
		11	S	U	75	100	13	250	Dlh	u
		12	S-EF	O	1,000	750	18	090	Dlh	u
		13	C	U	150	500	27	210	Dlh	u
		14	C	U	100	120	20	040	Dlh	u
		15	DF	O	2,000	900	14	095	Dck	c
		16	DF	O	600	300	20	330	Dck	u
		17	DF	O	2,100	500	18	340	MDhm-Dck	u
		18	DF	O	1,000	350	17	330	MDhm	u
		19	DF	O	5,000	1,150	11	345	MDhm-Dck	u
		20	DF	O	1,100	200	22	200	Dck	u
		21	C	R	250	550	32	150	Dck	u
		22	DS	O	1,800	500	24	345	MDhm-Dck	u
		23	DS	U	1,000	1,000	23	350	Dck	u
		24	DS	U	350	150	29	330	Dck	u
Linden	319	1	S-EF	O	1,250	900	28	040	Dlh	c
		2	C	O	300	400	54	160	Dck	u
		3	S	U	200	700	30	270	Dlh	u
		4	RF/RS	U	100	500	41	170	Dlh	r
		5	RF/RS	R	75	150	80	175	Dbh	r

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Linden	319	6	RF/RS	U	75	150	27	220	Dh	r
(continued)		7	RF/RS	U	50	900	80	230	Dbh	r
		8	C	R	100	125	20	220	Dlh	u
		9	C	O	1,200	100	32	330	St	u
		10	DA	U	500	160	64	145	Oj	u
		11	DA	U	500	75	60	086	Oj	t
		12	C	R	100	100	60	030	Obe	u
		13	C	R	50	350	50	230	Obe	c
		14	C	R	100	200	40	235	Dh	t
		15	C	R	50	60	20	260	Dh	u
		16	C	O	150	400	67	335	St	u
		17	C	O	1,000	780	40	300	St	u
		18	S	R	50	1,000	20	330	Sc	u
		19	C	R	300	150	70	210	Or	c
		20	S	U	50	1,200	20	290	Ocn	c
		21	C	U	250	500	64	130	Dck	c
Lock Haven	317	1	C	R	450	1,600	22	320	DSkm	c
		2	C	R	150	100	40	335	Sc	c
		3	C	R	150	100	40	345	Sc	c
		4	C	R	150	750	20	335	Sc	u
		5	C	O	1,400	1,150	37	335	MDhm	u
		6	C	O	450	400	53	240	MDhm	u
		7	C	O	150	300	67	230	MDhm	c
		8	C	R	250	125	33	350	Dbh	u
		9	DA	U	1,250	100	26	130	Dbh	u
		10	DA	U	900	100	27	135	Dbh	u
Mansfield	88	1	S	U	275	1,250	66	315	Dck-Dlh	lc
		2	S	U	300	750	27	115	Dlh	lc
		3	S	O	1,100	800	18	160	Dck	t
		4	C	R	75	200	7	160	Dck	lc
		5	C	R	250	1,250	32	230	Dck	t
		6	C	U	125	500	16	290	Dck	lc
		7	C	U	75	200	13	095	Dck	u
		8	C	R	240	700	8	230	Dck	u
		9	C	R	200	450	5	300	Dlh	lc
		10	C	U	250	450	12	270	Dck-Dlh	u
		11	C	U	100	375	60	170	Dck	lc
		12	S	O	900	1,000	22	120	Dck	lc
		13	S	U	250	550	4	225	Dlh	lc
		14	C	R	300	750	10	240	Dlh	u
		15	C	R	350	750	11	265	Dlh	u
		16	C	R	150	300	27	145	Dlh	lc
		17	C	R	150	600	20	320	Dlh	u
		18	C	O	1,050	3,025	11	140	Dlh	c
		19	S	R	500	1,050	20	310	Dlh	u
		20	C	R	250	750	20	050	Dlh	u
		21	S	R	250	550	16	225	Dlh	lc
		22	S	R	150	450	7	140	Dlh	lc
		23	S	R	250	600	26	135	Dlh	lc
		24	S	R	150	400	10	320	Dlh	lc
		25	S	R	100	300	25	140	Dlh	lc
		26	S	R	100	300	10	350	Dlh	lc
		27	C	U	200	2,000	30	335	Dlh	u
		28	S	R	250	750	32	155	Dlh	u
		29	C	U	1,900	250	8	050	Dlh	u
		30	C	RA	900	1,750	11	270	Dlh	u
		31	C	O	300	1,025	20	250	Dlh	u
		32	S	R	150	750	20	140	Dlh	u
		33	S	R	150	750	27	045	Dlh	u
		34	S	R	150	500	13	175	Dlh	u
		35	S	R	200	300	15	045	Dlh	t
		36	S	U	175	250	6	050	Dlh	u
		37	S	U	200	500	12	230	Dlh	u
		38	S	R	450	750	20	185	Dlh	u
		39	S	R	75	500	7	350	Dlh	u
		40	S	R	450	1,500	22	170	Dlh	u
		41	S	U	100	200	15	005	Dlh	u
		42	S	U	500	500	38	025	Dlh	lc
		43	S	U	400	600	4	040	Dlh	lc

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Mansfield *(continued)*	88	44	S	U	450	1,600	16	050	Dlh	lc
		45	S	U	500	1,500	20	250	Dlh	lc
		46	S	U	300	700	17	140	Dlh	lc
		47	S	U	500	555	10	240	Dlh	lc
		48	S	U	300	1,000	17	170	Dlh	lc
		49	S	U	250	500	8	355	Dlh	lc
		50	S	U	250	1,000	12	003	Dlh	u
		51	S	O	1,250	1,650	14	195	Dlh	lc
		52	S	O	725	600	11	215	Dlh	lc
		53	S	O	700	2,000	17	175	Dlh	lc
		54	C	RA	700	4,000	14	015	Dlh	u
		55	C	O	330	350	18	065	Dlh	u
		56	S	U	200	500	20	095	Dlh	u
		57	S	O	400	1,000	20	240	Dlh	u
		58	S	O	700	1,000	11	180	Dlh	u
		59	S	U	500	450	9	350	Dlh	u
		60	S	U	150	300	17	155	Dlh	u
		61	S	U	150	400	27	270	Dlh	u
		62	S	U	50	300	20	240	Dlh	u
		63	S	U	100	450	8	100	Dlh	u
		64	S	U	100	350	15	035	Dlh	u
		65	S	R	125	1,000	8	030	Dlh	u
		66	S	R	200	500	20	260	MDhm-Dck	t
		67	S	R	200	500	20	265	MDhm-Dck	t
Marshlands	129	1	C	O	1,100	500	20	196	MDhm	u
		2	S-EF	O	1,000	750	26	320	Dck	t
		3	S-EF	O	2,100	750	37	308	MDhm-Dck	t
		4	C	R	225	175	11	180	Mdhm	u
		5	DF	O	2,600	1,300	20	154	Dck	u
		6	C	O	1,150	900	23	325	Dck	t
		7	C	R	50	600	40	270	Dlh	t
		8	S	R	125	100	8	270	Dlh	t
		9	S	R	100	475	10	260	Dlh	t
		10	S-EF	O	1,750	975	17	263	Dck-Dlh	t
		11	C	O	600	1,000	20	155	Dck	t
		12	DF	O	1,750	750	18	175	MDhm-Dck	t
		13	DF	O	2,000	1,000	24	100	Dck	u
		14	DA	R	650	125	13	010	Dck	c
		15	S	R	360	100	11	190	Dck	u
		16	S-EF	O	700	1,100	18	248	Dck	t
		17	C	R	150	130	20	190	Dck	t
		18	S	U	350	330	31	238	Dck	t
		19	S	R	150	135	20	205	Dck	u
		20	S	R	150	125	7	025	Dck	u
		21	S	R	300	175	8	110	Dck	u
		22	S	U	75	110	11	130	Dck	u
		23	S	U	250	225	40	295	MDhm	u
		24	S	U	150	150	50	240	MDhm	u
		25	DF	O	1,225	500	24	292	MDhm	u
Meshoppen	186	1	S	O	200	800	13	204	Dck	t
		2	S	O	680	1,375	29	278	Dck	c
		3	DS	O	485	145	13	003	Dck	t
		4	S	O	850	1,500	17	040	Dck	t
		5	DS	R	200	355	33	102	Dck	t
		6	DS	R	460	120	13	205	Dck	c
		7	DA	R	580	90	36	235	Dck	c
		8	S	U	90	270	22	278	Dck	t
Mifflinville	373	1	DA	O	750	175	43	350	Dh	c
		2	DA	U	270	95	30	048	Dtr	c
		3	S	R	100	220	20	010	Mmc	t
Millerton	46	2	DS	R	100	400	60	130	Dlh	t
		3	DS	R	100	325	65	154	Dlh	t
		4	S-EF	R	175	250	34	160	Dlh	t
		5	DS	R	200	525	35	155	Dlh	t
		6	DS	R	100	225	25	100	Dlh	t
		7	DS	O	125	250	40	110	Dlh	t
		8	DS	O	175	400	57	268	Dlh	t
		9	DS	O	100	200	35	133	Dlh	t

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Millerton *(continued)*	46	10	DS	O	280	900	14	108	Dlh	t
		11	DS	R	300	1,000	16	308	Dlh	t
		12	DS	O	110	100	18	180	Dlh	t
		13	DS	O	105	100	52	240	Dlh	t
Millville	371	1	DA	O	650	100	8	026	Dh	c
		2	DA	O	300	150	10	029	Dh	c
Milton	369	1	S	R	75	100	13	310	Swc	u
		2	DS	R	150	100	27	235	Sbm	c
		3	RF/RS	R	100	100	40	090	Doo	r
Monroeton	138	1	C	U	1,500	1,650	15	015	Dck	g
		2	S	U	100	200	70	203	Dlh	u
		3	S-EF	O	575	1,300	16	345	Dck-Dlh	t
Montoursville North	273	1	C	U	140	300	43	339	Dck	g
		2	DS	U	75	80	27	125	Dlh	u
		3	DS	R	200	850	75	070	MDhm-Dck	c
		4	S	R	80	100	13	315	Dck	c
		5	S	O	100	200	20	250	Dbh	c
		6	DS	O	350	100	43	093	Dlh	c
		7	DS	O	450	100	38	093	Dlh	c
		8	DS	O	155	150	13	255	Dlh	t
		9	DS	R	350	200	29	260	Dlh	u
		10	DA	R	100	300	120	035	Dlh	c
		11	DS	O	600	200	33	170	Dck	c
Montoursville South	321	1	RF/RS	O	450	200	42	032	St	bc
		2	S	R	150	300	20	355	Sc	c
		3	S	O	200	250	29	340	Sc	c
		4	C	O	2,250	1,400	39	210	Obe	bc
		5	DF	O	250	300	75	105	Dtr	u
		6	DF	O	150	250	80	110	Dh	u
		7	DF	O	150	200	27	122	Dh	u
		8	DF	O	150	150	80	110	Dh	u
		9	DS	R	150	300	27	010	St	bc
		10	DS	R	200	150	45	355	St	bc
		11	DS	R	550	200	36	000	St	bc
		12	DS	R	150	250	67	358	St	bc
		13	DS	R	100	200	40	012	St	bc
Morris	176	1	S	O	150	320	33	342	Dck	t
		2	S	O	115	230	61	220	Dck	t
		3	S	O	115	710	52	237	Dck	t
		4	S	O	150	300	13	262	Dck	t
Muncy	322	1	S	O	180	900	33	030	St	bc
		2	S	O	100	450	10	026	St	bc
		3	S	O	100	400	30	020	St	bc
		4	S	O	80	200	38	005	St	bc
		5	S	O	100	300	30	010	St	bc
		6	S	O	100	300	30	005	St	bc
		7	S	O	70	225	29	002	St	bc
		8	S	O	150	100	53	000	St	bc
Nanticoke	328	1	RF/RS	O	1,600	1,400	33	136	Dck	c
		2	DS	R	520	440	54	148	Dck	bc
		3	C	R	150	140	47	150	Dck	g
		4	C	R	140	190	43	140	Dck	g
		5	*See Shickshinny quadrangle (number 327), landslide 14*							
Nauvoo	177	1	*See Liberty quadrangle (number 178), landslide 15*							
Noxen	232	1	DA	O	1,050	170	45	252	Dck	bc
		2	C	O	480	655	33	314	Dck	t
		3	DS	O	940	700	32	270	Dck	bc
		4	C	O	580	600	45	240	Dck	bc
		5	DS	O	500	150	16	286	Dck	c
		6	S	O	280	160	57	327	Dck	g
		7	S	O	400	300	15	326	Dck	g
		8	DS	O	1,490	295	28	260	Dck	bc
Oleona	173	1	S	U	75	100	13	250	Dck	u
		2	C	U	100	200	40	060	MDhm	u
		3	DF	O	2,300	900	25	105	MDhm-Dck	bc
		4	S	R	125	75	80	260	MDhm-Dck	u
		5	C	O	600	175	32	245	MDhm-Dck	u

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Oleona	173	6	C	O	1,650	1,000	38	148	MDhm-Dck	u
(continued)		7	C	R	75	75	—	315	Dck	u
		8	C	R	75	50	—	315	Dck	u
		9	C	R	100	50	—	315	Dck	u
		10	C	R	100	60	—	315	Dck	u
		11	C	O	75	700	47	270	Dck	u
		12	C	R	50	450	40	268	Dck	u
		13	C	O	1,275	750	41	100	MDhm-Dck	u
		14	C	O	1,500	1,400	32	080	MDhm-Dck	c
		15	C	R	175	100	72	310	Dck	u
		16	C	R	150	100	72	310	Dck	u
		17	C	R	75	75	72	310	Dck	u
		18	C	R	400	300	33	293	Dck	u
		19	S	O	400	500	60	325	MDhm-Dck	u
		20	C	U	75	550	27	320	Dck	u
		21	C	R	50	75	—	310	Dck	u
		22	C	R	50	75	—	310	Dck	u
		23	C	R	50	75	—	310	Dck	u
		24	S	U	100	125	40	030	Dck	u
		25	DF	O	875	300	12	278	Dck	u
		26	C	R	100	450	40	040	Dck	u
		27	DF	O	100	500	12	020	Dck	c
		28	DF	O	1,050	550	13	240	Dck	u
		29	DA	O	560	100	28	328	Dck	u
		30	*See Short Run quadrangle (number 172), landslide 6*							
Picture Rocks	275	1	DS	R	60	50	100	235	MDhm	c
Potter Brook	41	1	DF	O	2,725	2,000	12	268	Dlh	g
		2	S	O	1,625	1,275	13	078	Dlh	u
		3	DF	O	2,275	1,625	15	097	Dck-Dlh	g
		4	S-EF	R	150	150	17	090	Dlh	u
		5	S-EF	O	1,475	495	2	260	Dck	u
		6	S-EF	O	1,650	1,075	21	072	Dck	g
		7	DF	O	2,925	1,225	10	060	Dck	g
		8	S-EF	O	2,175	950	11	295	Dlh	u
		9	S-EF	O	3,175	1,975	15	332	Dck-Dlh	u
		10	S	O	1,225	1,075	24	255	Dck	u
		11	C	O	2,500	2,225	13	110	Dck	u
		12	S	U	225	500	22	170	Dlh	u
		13	C	O	1,075	825	22	075	Dck	u
		14	C	O	1,725	1,175	16	160	Dck	u
		15	DS	RA	1,900	700	16	039	Dck	u
		16	S	RA	110	325	9	020	Dck	u
		17	S-EF	O	1,025	425	19	228	Dck	u
		18	S-EF	O	1,375	1,225	13	062	Dck	u
		19	S-EF	O	2,325	875	19	110	MDhm-Dck	u
		20	DF	O	1,875	1,200	19	131	Dck	u
		21	S	O	625	1,350	14	050	Dck	u
		22	S	R	675	1,500	25	050	Dck	u
		23	S	R	425	375	20	025	Dck-Dlh	u
		24	C	O	1,065	575	42	284	Dck-Dlh	u
		25	S-EF	O	1,850	525	20	284	Dck	u
		26	S	R	425	350	21	230	Dlh	u
		27	C	RA	1,120	640	18	288	Dlh	u
		28	S	R	350	225	8	300	Dlh	u
		29	S	U	55	175	27	040	Dlh	u
		30	S	R	250	550	4	130	Dlh	lc
		31	S	U	40	100	38	205	Dlh	lc
		32	S	U	50	150	40	165	Dlh	lc
		33	S	U	100	225	40	175	Dlh	lc
		34	S	U	175	350	26	215	Dlh	lc
		35	S	U	300	225	15	200	Dlh	lc
		36	S	U	150	1,000	27	330	Dlh	lc
		37	C	U	245	460	4	350	Dlh	lc
		38	S-EF	O	1,910	900	12	330	Dck-Dlh	u
		39	S	R	375	275	53	075	Dlh	u
		40	S-EF	O	1,225	925	15	249	Dck	u
		41	S-EF	O	900	375	16	249	Dck	u
		42	S-EF	O	2,375	650	13	234	Dlh	u

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Potter Brook	41	43	S-EF	R	475	300	11	065	Dlh	u
(continued)		44	S	R	425	175	11	155	Dlh	u
		45	S-EF	R	1,100	150	16	280	Dlh	u
		46	S-EF	O	550	265	13	091	Dck	u
		47	C	O	1,375	675	13	215	Dck	u
		48	S-EF	U	1,575	825	6	225	Dck	u
		49	S	R	250	275	9	270	Dck	u
		50	C	R	225	75	11	250	Dck	u
		51	S	O	1,200	2,000	13	155	Dlh	lc
		52	DF	O	1,575	900	13	093	Dck-Dlh	g
		53	*See Sabinsville quadrangle (number 84), landslide 2*							
		54	S	R	250	400	16	005	Dlh	lc
		55	S	R	200	550	18	350	Dlh	lc
		56	S	R	800	1,200	8	160	Dlh	lc
		57	S	R	350	1,250	13	345	Dlh	lc
		58	S	R	250	400	14	175	Dlh	lc
		59	S	R	450	800	16	165	Dlh	lc
		60	S	R	350	875	13	325	Dlh	lc
		61	S	R	300	425	10	285	Dlh	lc
		62	S	R	250	950	20	000	Dlh	lc
		63	S	O	1,300	1,050	8	150	Dck-Dlh	lc
		64	S	R	325	550	15	215	Dck	g
		65	S	R	450	1,720	20	205	Dck	lc
		66	S	R	250	800	24	260	Dck	g
		67	S	R	300	925	25	220	Dck	lc
		68	S	R	300	750	17	125	Dck	lc
		69	S	R	350	500	14	050	Dck-Dlh	lc
		70	S	R	200	750	10	070	Dlh	lc
		71	S	R	325	1,000	12	080	Dlh	lc
		72	S	R	425	1,650	16	075	Dlh	g
		73	S	R	150	550	17	075	Dlh	g
		74	S	R	200	550	15	270	Dlh	g
		75	S	R	250	1,150	24	100	Dlh	lc
		76	S	R	300	1,150	20	070	Dlh	lc
		77	S	U	550	250	9	350	Dlh	lc
		78	S	U	200	250	8	185	Dlh	lc
		79	S	R	250	275	11	270	Dck	lc
Powell	137	1	S-EF	O	230	900	13	118	Dlh	t
		2	S-EF	O	780	1,790	10	180	Dlh	t
		3	S	O	130	95	8	076	Dlh	t
		4	S	O	190	270	21	265	MDhm	t
		5	S-EF	O	600	870	18	181	Dlh	g
		6	S-EF	O	750	870	13	175	Dlh	t
		7	S-EF	O	400	1,500	13	211	Dlh	t
		8	S-EF	O	680	780	25	175	Dlh	t
		9	S-EF	O	250	950	13	350	Dck	t
		10	S-EF	O	250	600	28	032	Dck	t
		11	S-EF	O	290	600	17	351	Dck	t
		12	S-EF	O	700	500	7	002	Dck	t
		13	DS	O	1,010	385	14	094	Dlh	t
		14	S-EF	O	400	800	13	165	Dlh	t
		15	C	O	1,200	70	8	345	Dck	t
		16	S	R	200	800	30	340	Dck	t
		17	C	R	1,300	2,300	29	208	MDhm	c
Ralston	179	1	S-EF	R	250	450	68	130	Dlh	t
		2	S-EF	R	250	450	32	050	Dlh	t
		3	DS	R	200	100	20	240	Dlh	t
		4	DA	R	300	200	60	175	Dlh	c
		5	DS	R	175	300	34	140	Dlh	c
		6	DS	R	200	250	80	220	Dlh	c
		7	DA	O	1,100	200	46	280	Dlh	c
		8	DA	O	1,100	150	45	280	Dlh	c
		9	RF/RS	O	2,000	1,500	40	315	MDhm	r
		10	DS	O	200	450	25	215	MDhm	c
		11	*See Bodines quadrangle (number 225), landslide 2*							
Renovo East	267	1	C	R	450	250	60	080	MDhm	u
		2	S	R	200	200	40	265	MDhm	u
		3	RF/RS	R	225	1,700	133	205	Dck	r

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Renovo East *(continued)*	267	4	RF/RS	R	225	300	142	205	Dck	r
		5	RF/RS	R	200	600	110	200	Dck	r
		6	DF	O	1,650	500	39	210	MDhm-Dck	c
		7	DS	R	100	150	30	315	Dck	u
		8	S	R	250	250	12	000	Dck	u
		9	DF	O	550	250	42	130	MDhm-Dck	bc
		10	DF	O	625	100	42	290	MDhm	bc
		11	DS	O	840	275	41	350	MDhm	u
		12	DA	O	1,250	250	54	355	MDhm-Dck	bc
		13	DA	O	1,120	275	59	350	MDhm-Dck	bc
		14	DS	O	1,275	300	55	030	MDhm-Dck	bc
		15	DS	O	1,050	200	69	348	MDhm-Dck	bc
		16	DS	O	1,150	150	67	348	MDhm-Dck	bc
		17	DS	O	700	100	74	343	MDhm-Dck	bc
		18	DS	O	650	120	77	331	MDhm-Dck	bc
		19	DS	O	700	50	74	328	MDhm-Dck	bc
		20	DS	O	575	250	87	312	MDhm-Dck	bc
		21	DS	O	250	150	64	292	Dck	bc
		22	DS	R	700	50	83	301	MDhm-Dck	bc
		23	DS	R	750	75	80	305	MDhm-Dck	bc
		24	DS	O	650	350	42	254	MDhm	u
		25	DS	O	1,175	300	28	268	MDhm	u
		26	DA	R	525	150	70	008	Dck	u
		27	DS	R	275	200	95	026	Dck	u
		28	S	O	950	950	47	309	MDhm	u
		29	S	O	350	350	40	327	MDhm	u
		30	C	O	1,750	1,300	18	260	Mb-MDhm	c
		31	C	O	1,450	950	28	315	MDhm	c
Renovo West	266	1	C	R	500	400	13	225	Mb	u
		2	C	O	600	950	20	090	Mb	c
		3	DF	O	1,300	650	9	240	Mb	c
		4	C	O	1,250	1,450	14	110	IPp-Mb	c
		5	S	R	250	325	32	220	Mb	u
		6	S	U	100	250	60	135	Mb	u
		7	DA	U	600	125	83	310	MDhm	u
		8	C	R	350	1,500	69	250	MDhm	u
		9	C	O	1,150	2,300	21	160	MDhm	c
		10	C	U	100	500	11	150	MDhm	u
		11	DS	R	200	125	110	230	MDhm	u
		12	DS	R	200	75	110	230	MDhm	u
		13	RF/RS	U	100	1,750	100	225	MDhm	r
		14	DF	O	1,750	900	24	030	MDhm	c
		15	C	O	750	925	66	315	MDhm	u
		16	C	R	500	2,500	64	035	MDhm	u
		17	C	R	175	1,300	91	100	Dck	u
		18	DA	R	675	40	89	200	MDhm	c
		19	DA	R	525	40	88	205	MDhm	c
		20	C	RA	1,150	1,100	26	160	MDhm	c
		21	DA	R	1,300	100	57	300	MDhm	c
		22	C	R	600	700	50	105	MDhm-Dck	u
		23	DA	U	1,150	400	61	295	MDhm-Dck	u
		24	DA	U	1,200	300	65	355	MDhm-Dck	u
		25	S	R	250	350	60	025	MDhm-Dck	u
		26	C	O	2,250	1,400	42	340	Mb-MDhm	u
		27	DA	O	600	50	87	340	MDhm	c
		28	DA	O	600	50	83	340	MDhm	c
		29	DA	O	725	50	88	305	MDhm	c
		30	DA	O	600	100	100	305	MDhm	c
		31	DA	O	900	25	82	300	MDhm	c
		32	DA	O	800	50	85	310	MDhm	c
		33	DS	R	500	500	64	035	IPp	f
Roseville	89	1	S	R	350	275	17	208	Dlh	t
		2	DS	R	1,250	800	4	350	Dck-Dlh	c
		3	DS	O	100	175	15	210	Dlh	t
		4	DA	U	1,050	100	25	355	Dck	c
		5	DS	R	225	375	28	170	Dck-Dlh	t
		6	DS	R	125	575	24	220	Dlh	t
		7	DS	R	125	200	16	240	Dlh	t
		8	DS	U	50	100	10	094	Dck	u

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Sabinsville	84	1	*See Potter Brook quadrangle (number 41), landslide 52*							
		2	DF	O	2,075	825	7	035	Dlh	g
		3	C	U	100	425	50	140	Dlh	u
		4	C	U	100	900	60	135	Dlh	u
		5	C	U	225	125	58	140	Dlh	u
		6	C	U	75	400	53	100	Dlh	u
		7	C	U	250	275	32	062	Dlh	u
		8	S	R	150	150	<10	150	Dlh	lc
		9	S	U	75	225	27	318	Dck-Dlh	u
		10	DF	O	1,800	1,025	21	090	Dck-Dlh	t
		11	S	U	50	300	<10	260	Dck	lc
		12	S	U	50	425	<10	230	Dck	lc
		13	C	U	50	75	20	225	Dck	u
		14	C	U	100	275	20	190	Dck	u
		15	C	U	50	300	60	180	Dck	u
		16	C	U	150	575	67	080	MDhm	u
		17	S	U	175	425	29	050	MDhm	u
		18	C	R	75	400	13	060	Dck	g
		19	C	R	100	500	10	015	Dck	g
		20	C	R	150	100	33	125	Dck	g
		21	C	R	225	1,150	31	130	Dck	c
		22	C	R	150	1,000	27	145	Dck	c
		23	C	R	200	1,000	45	180	Dck	c
Sayre	49	1	S	O	380	750	17	130	Dlh	lc
		2	S	R	200	1,150	15	198	Dlh	lc
		3	S	R	150	110	80	290	Dlh	c
		4	S	R	130	90	69	270	Dlh	c
		5	S	R	125	115	24	228	Dlh	c
Shickshinny	327	1	S	R	140	150	14	185	Dtr	c
		2	DS	R	300	130	20	250	Dtr	c
		3	DS	O	650	170	39	270	Dtr	bc
		4	S	R	95	160	11	330	Dtr	u
		5	DS	R	680	400	35	060	ℙl	f
		6	DS	R	270	230	15	075	ℙl	f
		7	S	R	—	—	—	—	ℙl	f
		8	DF	O	540	95	9	245	Dck	c
		9	S	R	310	690	58	220	ℙl	f
		10	S	R	310	200	58	235	ℙp	f
		11	RF/RS	O	180	175	28	145	Mmc	bc
		12	RF/RS	O	215	180	47	090	Mmc	bc
		13	RF/RS	O	220	150	59	082	Mmc	bc
		14	S	O	1,650	1,180	41	150	Mp	c
Short Run	172	1	DS	U	1,100	200	36	003	MDhm-Dck	u
		2	DA	U	900	200	29	335	Dck	u
		3	C	O	1,700	600	14	320	Dck	u
		4	DA	U	1,100	175	26	020	Dck	u
		5	RF/RS	R	150	750	27	060	Dlh	r
		6	C	O	1,750	750	39	142	Dck	c
		7	C	O	900	600	21	022	Dck	u
		8	C	O	500	500	32	310	Dck	u
		9	DA	U	1,850	250	32	035	MDhm-Dck	u
		10	DF	RA	1,700	600	42	290	Dck	c
		11	DA	U	400	250	38	290	MDhm	u
		12	DF	O	1,500	350	45	048	MDhm	c
		13	DF	O	1,450	300	45	048	MDhm	c
		14	DF	O	1,150	350	46	020	MDhm	c
		15	C	O	1,050	700	25	140	Dck	u
		16	C	O	3,450	2,250	15	340	MDhm-Dck	c
		17	S-EF	O	800	600	60	130	MDhm	c
		18	S-EF	O	850	450	48	046	MDhm	c
		19	S-EF	O	1,050	300	44	080	MDhm	c
Slate Run	220	1	DA	U	450	100	24	110	MDhm	u
		2	DF	U	350	100	46	320	MDhm	u
		3	C	O	400	300	50	345	MDhm-Dck	u
		4	DA	O	700	75	54	268	MDhm	u
		5	DA	O	750	100	43	265	MDhm	u
		6	DA	O	950	100	47	260	MDhm	u
		7	DA	O	850	150	49	290	MDhm	u
		8	DA	O	1,325	100	45	280	MDhm	u

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Slate Run	220	9	DA	R	1,250	100	45	320	MDhm-Dck	u
(continued)		10	DA	R	1,000	109	55	320	MDhm-Dck	u
Snow Shoe	360	1	*See Snow Shoe SE quadrangle (number 361), landslide 6*							
		2	S	R	650	375	20	200	Mmc-Mb	u
		3	C	R	375	875	35	035	Mb	f
		4	C	R	400	475	33	345	Mb	f
		5	C	R	375	700	29	330	Mb	f
Snow Shoe NE	314	1	DA	U	750	200	40	352	MDhm	u
		2	DA	U	1,400	350	51	345	MDhm	u
		3	DF	O	1,700	450	48	050	MDhm-Dck	c
		4	DA	U	500	200	48	095	MDhm	u
		5	DA	U	450	150	40	075	MDhm	u
		6	DF	O	1,500	550	17	350	MDhm	c
		7	DF	O	1,450	500	50	260	MDhm-Dck	c
		8	DF	O	1,000	400	56	240	MDhm	c
		9	DF	O	1,400	600	24	100	Mb	c
		10	C	O	750	400	16	230	Mb	u
		11	C	O	700	756	17	095	Mb	u
		12	S	RA	800	1,000	58	010	MDhm	u
		13	DF	O	1,500	750	40	015	MDhm	c
		14	DF	O	1,750	750	43	290	MDhm	c
		15	DF	O	2,500	750	10	042	Mb	c
		16	DF	O	1,300	750	12	265	Mb	c
Snow Shoe NW	313	1	DA	U	400	300	20	070	Mb	u
		2	S-EF	U	750	400	36	105	MDhm	u
		3	C	O	1,550	1,900	36	115	Mb-MDhm	u
		4	S	R	100	500	80	130	MDhm	u
		5	DF	U	2,000	400	28	320	Mb-MDhm	c
		6	DF	U	1,450	900	46	035	Mb-MDhm	c
		7	DA	U	500	2,500	110	140	MDhm	c
		8	C	O	1,250	1,300	22	110	MDhm	c
		9	RF/RS	U	100	3,500	20	230	MDhm	u
		10	RF/RS	U	100	300	20	140	Mb-MDhm	r
		11	C	RA	1,500	1,000	33	295	MDhm	u
		12	DF	O	1,550	650	57	295	MDhm	c
		13	DF	R	1,150	600	61	033	MDhm	c
		14	C	O	850	750	49	053	MDhm	u
		15	C	O	1,660	750	48	230	MDhm	u
		16	C	O	1,650	600	44	040	MDhm	u
Snow Shoe SE	361	1	C	O	2,150	1,450	13	083	IPp-Mmc-Mb	u
		2	DF	O	1,500	1,200	15	020	IPp-Mmc	c
		3	DF	O	1,825	500	25	185	IPp-Mmc-Mb	c
		4	A	O	850	1,000	25	045	IPp-Mmc	c
		5	DA	U	800	425	16	005	Mmc-Mb	u
		6	DF	O	1,050	600	25	150	Dck	c
		7	DF	O	1,075	325	15	022	Mb-MDr	c
		8	DF	O	1,350	650	31	150	Mb-MDr	c
		9	DF	O	2,550	1,200	24	165	MDr-Dck	c
		10	A	O	2,750	1,350	18	055	MDr-Dck	c
		11	DS	R	200	1,800	40	240	MDhm	c
Sonestown	276	1	DS	R	260	140	8	088	Dck	c
Sweden Valley	81	1	S-EF	O	900	550	33	284	MDhm	bc
		2	DF	O	1,800	100	8	160	Dck	c
		3	C	O	1,900	1,000	20	103	MDhm-Dck	u
		4	DS	O	600	700	33	310	Dck	u
		5	C	O	1,300	800	22	120	MDhm-Dck	u
		6	DF	O	950	400	8	114	MDhm-Dck	c
		7	DF	O	550	275	16	275	MDhm	u
		8	DF	O	1,200	300	18	305	MDhm	u
		9	C	O	1,100	1,000	18	140	Dck	c
		10	S-EF	R	250	200	18	150	Dck	c
		11	C	O	700	2,000	13	248	Dck	c
		12	DF	O	1,600	1,175	26	028	MDhm	bc
		13	DS	O	1,500	150	9	000	Dck	c
		14	DF	O	2,800	300	7	185	MDhm-Dck	c
		15	C	O	1,000	5,090	11	030	Dck	c
		16	C	O	300	275	17	310	Dck	u

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Sweden Valley	81	17	C	O	425	400	19	304	Dck	u
(continued)		18	C	R	350	175	7	250	Dck	u
		19	DF	O	1,300	225	15	208	MDhm	u
		20	C	O	600	700	27	288	Dck	u
		21	C	R	400	600	25	230	Dck	u
		22	DS	O	1,200	1,300	25	145	MDhm-Dck	u
		23	DF	O	1,200	400	20	180	Dck	u
		24	C	O	800	600	28	100	Dck	u
		25	C	O	525	1,000	19	300	Dck	u
		26	C	O	525	2,100	19	340	Dck	u
		27	C	O	600	900	13	310	Dck	u
		28	C	RA	900	325	26	340	Dck	u
		29	C	RA	225	300	36	350	Dck	u
		30	C	R	150	200	27	200	Dck	u
		31	C	R	150	200	33	210	Dck	u
		32	C	R	300	200	23	180	Dck	u
		33	C	O	800	1,500	33	220	Dck	u
		34	C	O	775	1,700	10	130	Dck	u
		35	DF	O	3,300	400	9	257	MDhm	bc
		36	DS	O	400	600	45	025	MDhm	u
		37	C	O	500	800	22	135	Dck	u
		38	S-EF	U	700	300	49	010	MDhm	u
		39	C	O	1,600	1,200	23	148	Dck	c
		40	C	O	650	1,300	19	120	Dck	c
		41	C	O	1,100	2,000	22	310	Dck	c
		42	DF	O	1,200	300	24	134	Dck	c
Sweet Valley	279	1	DS	O	500	450	12	086	Dck	u
Tamarack	218	1	S	U	350	700	86	140	Dck	u
		2	C	R	200	250	30	035	Dck	c
		3	S	R	150	500	27	335	Dck	u
		4	C	O	1,500	700	32	230	Dck	u
		5	C	O	500	1,000	50	040	Dck	u
		6	C	U	700	600	6	140	Dck	u
		7	C	O	950	500	13	045	MDhm-Dck	u
		8	S	U	350	600	55	230	MDhm	u
		9	C	O	150	200	27	130	Dck	c
Tiadaghton	130	1	DS	U	150	125	13	215	Dck	u
		2	DS	U	100	250	30	290	Dck-Dlh	u
		3	DS	U	50	125	40	285	Dck-Dlh	u
		4	DS	U	50	125	40	290	Dck-Dlh	u
		5	DS	U	100	125	40	300	Dck-Dlh	u
		6	DS	U	150	100	67	120	Dck-Dlh	r
		7	DA	U	250	100	76	328	Dck-Dlh	u
		8	DA	U	300	50	57	130	Dck-Dlh	u
		9	DF	O	400	350	25	130	Dck-Dlh	bc
		10	DS	U	125	150	48	130	Dck-Dlh	u
		11	C	O	350	425	23	075	Dck-Dlh	c
		12	DA	U	425	50	56	320	Dck-Dlh	u
		13	DS	U	200	200	40	140	Dck-Dlh	u
		14	DS	U	50	150	80	350	Dck-Dlh	u
		15	DS	U	100	200	80	005	Dck-Dlh	u
		16	DS	U	200	450	55	010	Dck-Dlh	u
		17	DA	U	250	50	80	357	Dck-Dlh	u
		18	DS	O	750	700	53	115	Dck-Dlh	u
		19	DS	O	1,025	350	60	340	Dck-Dlh	u
		20	*See Marshlands quadrangle (number 129), landslide 13*							
Tioga	44	1	S	R	110	150	18	351	Dlh	t
		2	S	R	60	350	67	245	Dlh	lc
		3	S	R	75	120	27	192	Dlh	lc
		4	S	R	25	500	20	220	Dlh	lc
		5	S	U	150	500	13	130	Dlh	u
		6	*See Jackson Summit quadrangle (number 45), landslide 9*							
		7	S	R	350	575	19	135	Dlh	lc
		8	S	R	250	450	12	185	Dlh	lc
		9	S	R	225	450	27	120	Dlh	g
		10	S	R	225	600	18	280	Dlh	lc
		11	S	R	200	250	28	355	Dlh	lc

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Tioga *(continued)*	44	12	S	R	150	275	37	185	Dlh	lc
		13	S	R	175	300	6	140	Dlh	lc
		14	S-EF	R	1,200	1,800	25	110	Dlh	g
Towanda	93	2	S	R	175	175	49	240	Dlh	t
		3	S	O	300	575	24	220	Dlh	t
		4	S	O	75	150	27	230	Dlh	t
		5	S	O	125	300	16	247	Dlh	t
		6	S	O	200	500	30	230	Dlh	t
		7	DS	R	75	100	80	220	Dlh	bc
		8	DS	R	100	75	35	200	Dlh	bc
		9	S	R	100	200	22	030	Dlh	t
		10	S	R	100	200	50	030	Dlh	t
Trout Run	224	1	S	U	200	300	10	340	Dck	u
		2	S	U	350	300	29	325	MDhm-Dck	u
		3	S	U	650	250	22	190	MDhm-Dck	u
		4	C	O	750	800	23	020	Dck	c
		5	DA	O	2,000	200	32	338	MDhm-Dck	u
		6	DS	O	2,350	450	20	215	MDhm-Dck	u
		7	C	O	450	1,300	42	240	Dck	c
		8	C	O	350	1,200	34	250	Dck	c
		9	C	O	1,750	150	45	027	Dck	c
		10	C	O	1,500	250	44	010	MDhm-Dck	c
		11	C	O	1,700	550	44	015	MDhm-Dck	c
		12	C	O	1,500	450	48	023	MDhm-Dck	c
		13	DA	O	750	100	56	357	MDhm	u
		14	DA	O	450	100	60	012	MDhm-Dck	u
		15	DA	O	1,250	200	56	018	MDhm-Dck	u
		16	DA	O	850	150	65	020	MDhm-Dck	u
		17	DF	O	1,700	300	49	050	MDhm-Dck	c
		18	C	U	125	175	56	095	Dck	u
		19	C	U	100	450	80	025	Dck	u
		20	DA	O	900	60	53	310	MDhm-Dck	u
		21	DA	O	1,000	65	49	280	MDhm-Dck	u
		22	DS	U	300	250	33	275	Dck	u
		23	C	U	450	600	22	150	Dck	u
		24	DF	O	1,850	350	37	290	MDhm-Dck	c
		25	DF	O	1,300	350	35	295	MDhm-Dck	c
		26	DF	O	2,000	500	25	320	MDhm-Dck	c
		28	DF	O	1,500	100	45	085	MDhm-Dck	c
		29	DF	O	1,750	250	49	050	MDhm-Dck	c
		30	DF	O	1,850	250	44	060	MDhm-Dck	c
		31	S	R	100	75	60	270	Dck	u
		32	DF	O	2,050	600	41	110	MDhm-Dck	c
		33	DF	U	400	100	63	330	Dck	bc
		34	DF	U	250	200	56	335	Dck	bc
		35	DF	U	600	175	50	335	Dck	bc
		36	DF	U	800	75	60	320	Dck	bc
		37	DF	U	450	250	49	340	Dck	bc
		38	S	U	250	450	24	140	MDhm-Dck	u
Troy	90	1	S	O	350	1,000	20	065	Dlh	t
		2	DS	R	150	100	40	250	Dck	t
		3	DA	O	2,500	200	27	100	MDhm-Dck	c
Ulster	92	1	S	O	1,175	1,250	11	025	Dlh	t
		2	S	O	500	1,200	15	220	Dlh	t
Ulysses	39	1	C	R	200	150	24	160	Dck	u
		2	DF	O	1,700	200	15	220	Dck	u
		3	S-EF	O	850	550	26	000	Dck	u
		4	C	O	1,650	875	17	028	Dck	u
		5	DF	O	1,000	800	22	170	Dck	c
		6	S-EF	O	400	375	10	140	Dck	u
		7	S-EF	O	1,500	700	20	090	Dck	u
		8	S-EF	O	900	500	23	105	Dck	u
		9	C	O	1,700	3,400	12	285	Dck	c
		10	DF	O	1,600	700	16	038	Dck	c
		11	C	O	1,250	1,800	21	120	Dck	u
		12	DF	O	1,600	750	16	275	Dck	bc
		13	C	R	300	175	30	140	Dck	u

Table 5. *(Continued)*

Quadrangle name	Quad-rangle number	Landslide number	Type	Age	Length (feet)	Width (feet)	Percent slope	Slope azimuth (degrees)	Bedrock geologic unit	Surficial geologic unit
Ulysses	39	14	S-EF	R	450	375	27	030	Dck	u
(continued)		15	C	O	1,000	3,300	6	060	Dck	c
		16	C	O	1,500	1,650	11	075	Dck	u
Washingtonville	370	1	DS	O	800	250	11	087	Dh	c
		2	DS	R	190	300	42	110	Dh	g
West Pike	83	1	DS	RA	75	100	27	280	Dck-Dlh	u
		2	C	U	100	250	40	140	Dck	c
		3	C	U	110	100	27	110	Dck	c
		4	S	U	250	575	24	350	MDhm	c
		5	DF	O	1,050	500	12	090	Dck	u
		6	S	U	275	525	16	150	Dck-Dlh	c
		7	DF	O	700	375	17	090	Dlh	c
		8	S	R	150	475	27	095	Dlh	t
		9	C	U	800	475	23	105	Dlh	t
		10	DF	O	2,500	525	14	280	Dck-Dlh	t
		11	DF	O	1,600	1,800	15	280	Dck-Dlh	t
		12	DF	O	2,350	1,300	14	275	Dck-Dlh	t
		13	C	R	50	1,600	40	300	Dlh	t
		14	C	R	75	150	53	105	Dlh	t
		15	C	R	75	350	26	100	Dlh	t
		16	S	U	175	225	34	320	Dlh	c
		17	DF	O	1,500	475	18	147	Dck	u
		18	DF	O	1,400	525	19	140	Dck	u
		19	DF	O	1,150	450	19	090	Dck-Dlh	t
		20	S-EF	R	250	325	10	160	Dlh	c
		21	S-EF	U	625	175	16	240	Dlh	u
		22	S	U	400	500	18	055	Dlh	g
		23	S	U	75	75	53	280	Dck	c
		24	S	U	50	400	60	270	Dck	c
		25	S	R	50	50	70	260	Dck	c
		26	C	U	125	100	24	230	Dck	c
		27	S	R	50	50	40	250	Dck	c
		28	S	R	150	350	25	185	Dck	c
		29	S	R	100	200	20	190	Dck	c
		30	C	U	50	100	20	210	Dck	c
		31	C	U	70	150	20	200	Dck	c
		32	C	U	80	250	20	200	Dck	c
		33	C	R	175	250	34	250	MDhm	u
		34	C	U	125	100	7	020	Dlh	c
White Pine	223	1		*See Trout Run quadrangle (number 224), landslide 2*						
		2		*See Trout Run quadrangle (number 224), landslide 3*						
Williamsport	320	1	C	R	160	500	44	180	Dlh	u
		2	C	R	75	250	13	025	Dh	f
		3	C	R	75	250	7	200	Dh	f
		4	C	R	50	200	6	220	Dh	f
		5	C	R	50	250	10	215	Dh	f
		6	C	U	150	300	1	185	Doo	f
		7	DS	O	1,000	1,000	17	343	Sr-St	c
		8	DS	O	750	450	31	350	Sc-St	c
		9	DS	O	950	250	34	345	Sr-St	c
		10	DS	O	750	100	32	348	Sr-St	c
		11	DS	O	1,400	450	39	350	Sr-St	u
		12	C	O	750	250	38	350	Sr	c
		13	C	U	150	400	67	200	Or	u
		14	C	U	250	750	40	210	Or	u
		15	C	O	500	150	30	300	Or	c
		16	C	R	100	150	40	150	St	bc
		17	C	R	175	350	74	160	St	bc
Young Womans Creek	219	1	S	U	175	350	46	250	Dck	u
		2	DA	U	450	100	62	255	MDhm	u
		3	C	R	250	200	44	250	MDhm	u
		4	C	O	1,375	350	58	307	MDhm-Dck	u
		5	DA	O	1,075	150	47	010	MDhm	u
		6	S	U	275	400	53	030	MDhm	u


ALLENWOOD PRISON CAMP
DELAWARE
GREGG
WASHINGTON
Allenwood
Dewart
SOUTH WHITE DEER RIDGE
LYCOMING CO
UNION CO
WEST BRANCH SUSQUEHANNA RIVER
NORTHUMBERLAND CO
White Deer Creek
NITTANY MOUNTAIN
Catharines Crown
BALD EAGLE STATE FOREST
WHITE DEER
Spruce Run Reservoir
BUFFALO MTN
BUFFALO
Kelly Crossroads
KELLY
West Milton
Spring Garden
1
2
3
4
5
6
7
8
SCALE ~1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
Interstate Route
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
ALLENWOOD

77°22'30"
41°45'
17'30"
WELLSBORO
Charleston
Russell Hill
Dean Hill
Wilson Creek
Shumway Hill
Roundtop
Coolidge Hollow
Stony Fork
Draper
Broughton Hollow
Goat Ranch Hill
Lost Hill
Antrim
D E L M A R
C H A R L E S T O N
D U N C A N
M O R R I S
TIOGA STATE FOREST
STATE GAME LANDS NO. 268
1
2
3
4
5
6
41°37'30"
77°15'
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Heavy duty
Light duty
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1966 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

ANTRIM

AUBURN CENTER

EULALIA
SWEDEN
Jenkins Hill
Ayers Hill
Coudersport Country Club
Cochran Hill
Rapid Hill
SUMMIT
Indian Shanty
Prouty Place
Prouty
Sinnemahoning
SYLVANIA
Lyman Run
East Fork
Hogback Hollow
West Branch
Fox Hill
2
4
11
13
16
18
19
20
22
23
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
HARD-SURFACE ALL WEATHER ROADS
DRY WEATHER ROADS
Heavy-duty
Improved dirt
Medium-duty
Unimproved dirt
Loose surface, graded, or narrow hard-surface
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1971 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

AYERS HILL

76°52'30"
41°30'
76°45'
41°30'
41°22'30"
76°52'30"
41°22'30"
76°45'
27'30"
25'
47'30"
50'
MCINTYRE
TIADAGHTON STATE FOREST
MCNETT
FOX
WYOMING STATE FOREST
CASCADE
HILLSGROVE
STATE GAME LANDS NO 134
PLUNKETTS CREEK
CAMP MOUNTAIN
Proctor
Barbours
Days Roundtop
Sprout Pond
Hoppestown
Scaife Knob
GAMBLE
LOYALSOCK CREEK
Coal Mine Hollow
Wallis Run
Mountain
1
2
3
4
5
6
7
8
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Medium duty
Light-duty
Unimproved dirt
State Route
UTM GRID AND 1973 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
PENNSYLVANIA
QUADRANGLE LOCATION

BARBOURS

BALD EAGLE
BEECH CREEK
Bunker Hill
Sugar Run
Peters Hollow
Beech Creek
Blanchard
LIBERTY
Eagleville
West Beech
Beech Creek Station
Beech Creek Gap
BALD EAGLE MOUNTAIN
LAMAR
Eagleville Gap
FOSTER JOSEPH SAYERS LAKE
PORTER
NITTANY VALLEY
MARION
LITTLE NITTANY VALLEY
WALKER
SAND RIDGE
Lamar
Lamar National Fish Hatchery
Cedar Run
Parvin Spring
Fishing Creek
1
2
3
4
5
6
7
8
9
10
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
Interstate Route
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

BEECH CREEK

BENTLEY CREEK


JACKSON
PINE
GREENWOOD
Benton
Stillwater
Jackson
Coles Mill
Derrs
Davis Hill
Ball Hill
O'Brien Hill
Polkville
Rohrsburg
Greenwood
Consolidated
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1975 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
BENTON


SALEM
NESCOPECK
BERWICK
SUSQUEHANNA
RIVER
Nescopeck
Foundryville
Berwick Heights
Glen Brook Reservoir
Beach Haven
Wapwallopen
Briggsville
Gould Island
LEE MOUNTAIN
NESCOPECK MOUNTAIN
BLACK CREEK
BEAVER
SCALE 1:62500
Contour interval 20 feet
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Heavy-duty
Medium-duty
Light-duty
Unimproved dirt
U.S. Route
State Route
Interstate Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1976 MAGNETIC NORTH

BERWICK


GREENWOOD VALLEY
GREENWOOD
FISHINGCREEK
Round Top
Wellversville
ORANGE
KNOB MOUNTAIN
Orangeville
North Centre
Millertown
Stone
SUMMER HILL
NORTH CENTRE
Light Street
Camp Creasy
Paper Mill
SOUTH CENTRE
SCOTT
TURKEY HILL
BLOOMSBURG
Buckhorn
Hemlock
Ferryville
Almedia
Espy
SUSQUEHANNA RIVER
MAIN
MOUNT PLEASANT
HEMLOCK
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Heavy duty
Light duty
Medium duty
Unimproved dirt
U.S. Route
State Route
Interstate Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1975 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
1
2
3
4
5
6
7
8
9

BLOOMSBURG


Covington
Blossburg
Morris Run
TIOGA STATE FOREST
HAMILTON
LIBERTY
UNION
PINE
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
PENNSYLVANIA
QUADRANGLE LOCATION

BLOSSBURG

MCINTYRE MOUNTAIN
SULLIVAN
POTASH MOUNTAIN
TIADAGHTON STATE FOREST
RIDGE
BURNETTS
CASCADE
LEWIS
BODINE MOUNTAIN
Bodines
STATE GAME LANDS NO 133
De Bois Hollow
Kellyburg
GAMBLE
JACOBY
MOUNTAIN
Calvert
Beech Valley Camp
Slacks Run
Lycoming
Penn Central
Wallis Run
Murray Run
Mill Creek
Blessing Mtn
Cold Run Hollow
Slaughter Hollow
Pleasant
Salt Run
Roaring Run
Jacoby Hollow
1
2
3
4
5
6
7
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy duty
Medium duty
Light duty
Unimproved dirt
State Route
UTM GRID AND 1973 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
PENNSYLVANIA
QUADRANGLE LOCATION

BODINES

77°52'30"
41°52'30"
77°45'
41°52'30"
41°45'
77°52'30"
77°45'
41°45'
50'
47'30"
1 990 000 FEET
620 000 FEET
580 000 FEET
1 970 000 FEET
Gold
Newfield Junction
Raymond
Fox Hill
Substation
Brookland
Walton
Sweden
Potato City
A L L E G A N Y
U L Y S S E S
S W E D E N
S U S Q U E H A N N O C K   S T A T E   F O R E S T
DENTON HILL STATE PARK
Woodcock Creek
Buckseller Run
Pine Creek
Ninemile Run
Homestead Hollow
Heath Hollow
Cross Hollow
Crowell Hollow
Lillis Hollow
Mill Hollow
Sweden Hill
PIPELINE
COUDERSPORT
PORT ALLEGANY
1
2
3
4
5
6
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11
12
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16
17
18
19
20
21
22
23
(CHERRY SPRINGS)
SCALE ~1:62500
1 MILE
1 KILOMETER
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
UTM GRID AND 1969 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
PENNSYLVANIA
QUADRANGLE LOCATION
ROAD CLASSIFICATION
Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U. S. Route
State Route

BROOKLAND

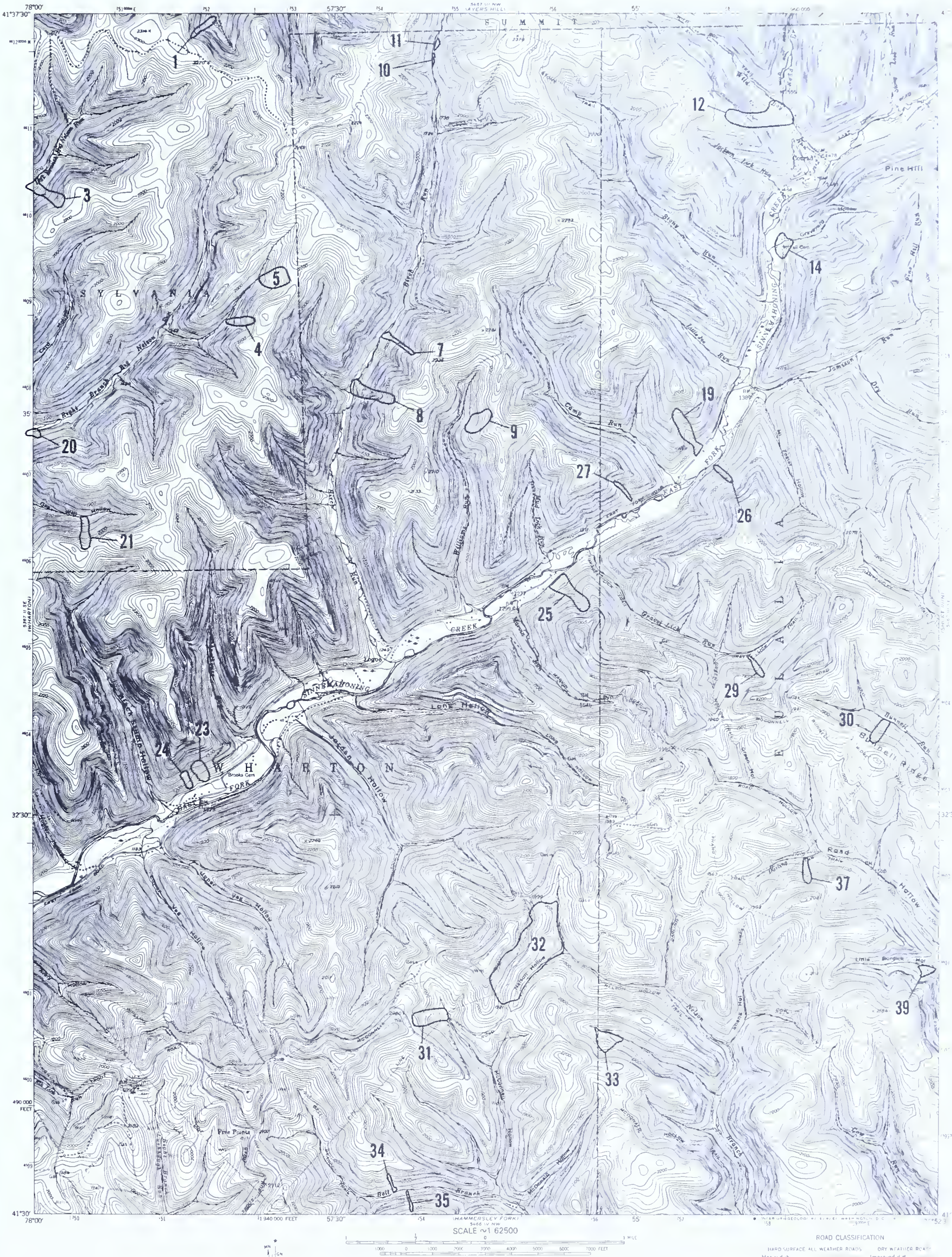

ARMENIA
MOUNTAIN
TROY
TIOGA STATE FOREST
Alba
Windfall
GRANVILLE
Granville Summit
North Branch Towanda Creek
Minnequa
CANTON
Canton
East Canton
Towanda Creek
LEROY
Mud Pond
Lake Nephawin
Beech Flats
Cedar Ledge
Lambs Hill Picnic Area
Wallace Brook
Williams Hollow
Beech Flats Creek
1
2
5
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U S Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1970 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

CANTON

CHERRY FLATS

CHERRY SPRINGS

COGAN STATION


1
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27
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31
32
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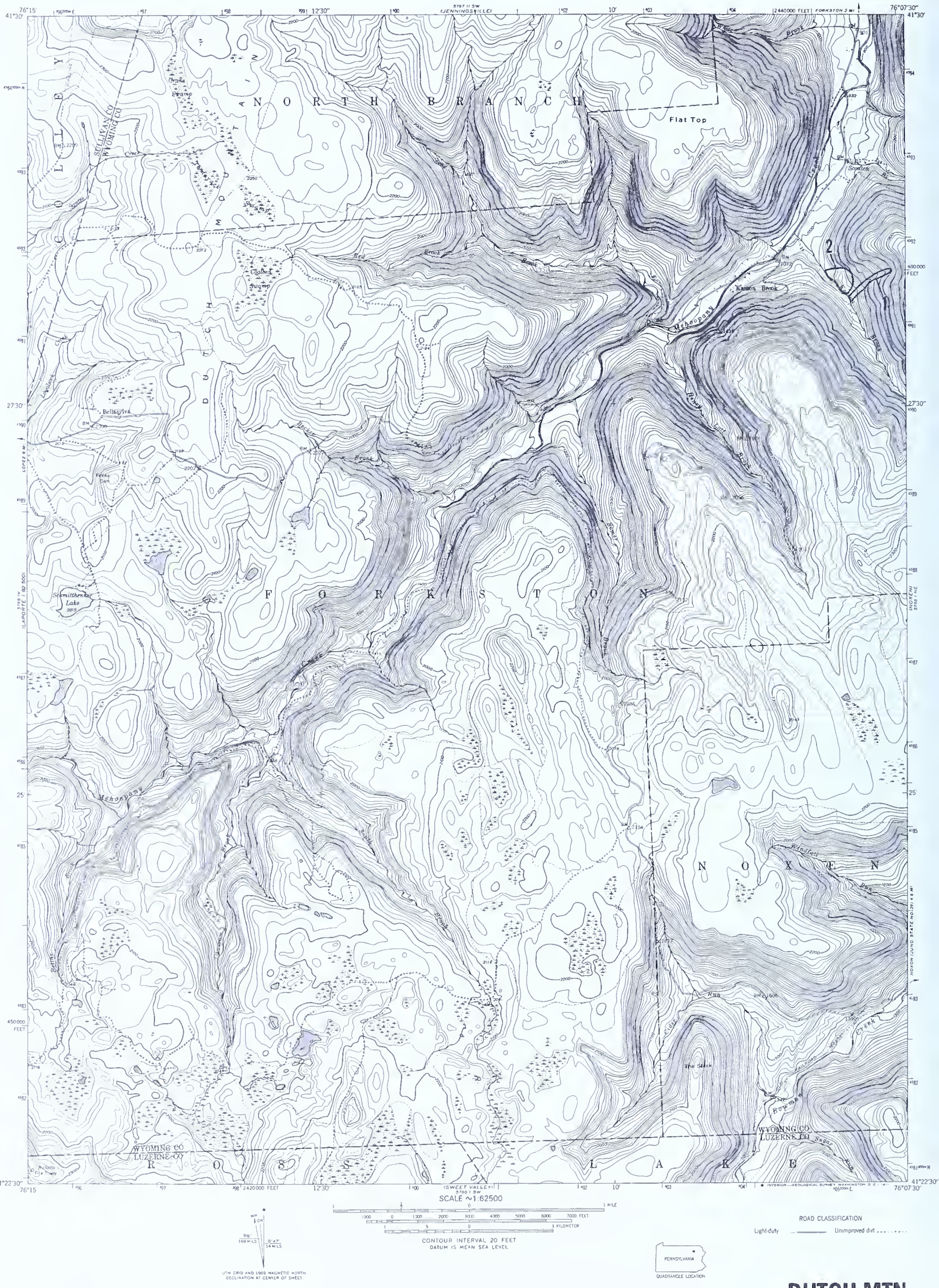
35
37
39
S U M M I T
S Y L V A N I A
W H A R T O N
SINNEMAHONING
CREEK
EAST
FORK
Pine Hill
Brooks Cem
Lone Hollow
Jordan Hollow
Bunnell Ridge
Pine Plains
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy duty
Medium duty
Improved dirt
Unimproved dirt
U. S. Route
State Route
78°00'
41°37'30"
57'30"
55'
32'30"
41°30'
490 000 FEET
1 940 000 FEET

CONRAD



76°15'
41°30'
12'30"
10'
76°07'30"
(JENNINGSVILLE)
FORKSTON 2 MI
NORTH BRANCH
Flat Top
Red Brook
Kasson Brook
Mehoopany
Bellasylva
Schmitthenner Lake
DUTCH MOUNTAIN
FORKSTON
NOXEN
ROSS LAKE
SULLIVAN CO
WYOMING CO
LUZERNE CO
The Stack
27'30"
25'
41°22'30"
2440000 FEET
480000 FEET
450000 FEET
2420000 FEET
(SWEET VALLEY)
SCALE 1:62500
1 MILE
1 KILOMETER
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Light-duty
Unimproved dirt
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1969 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

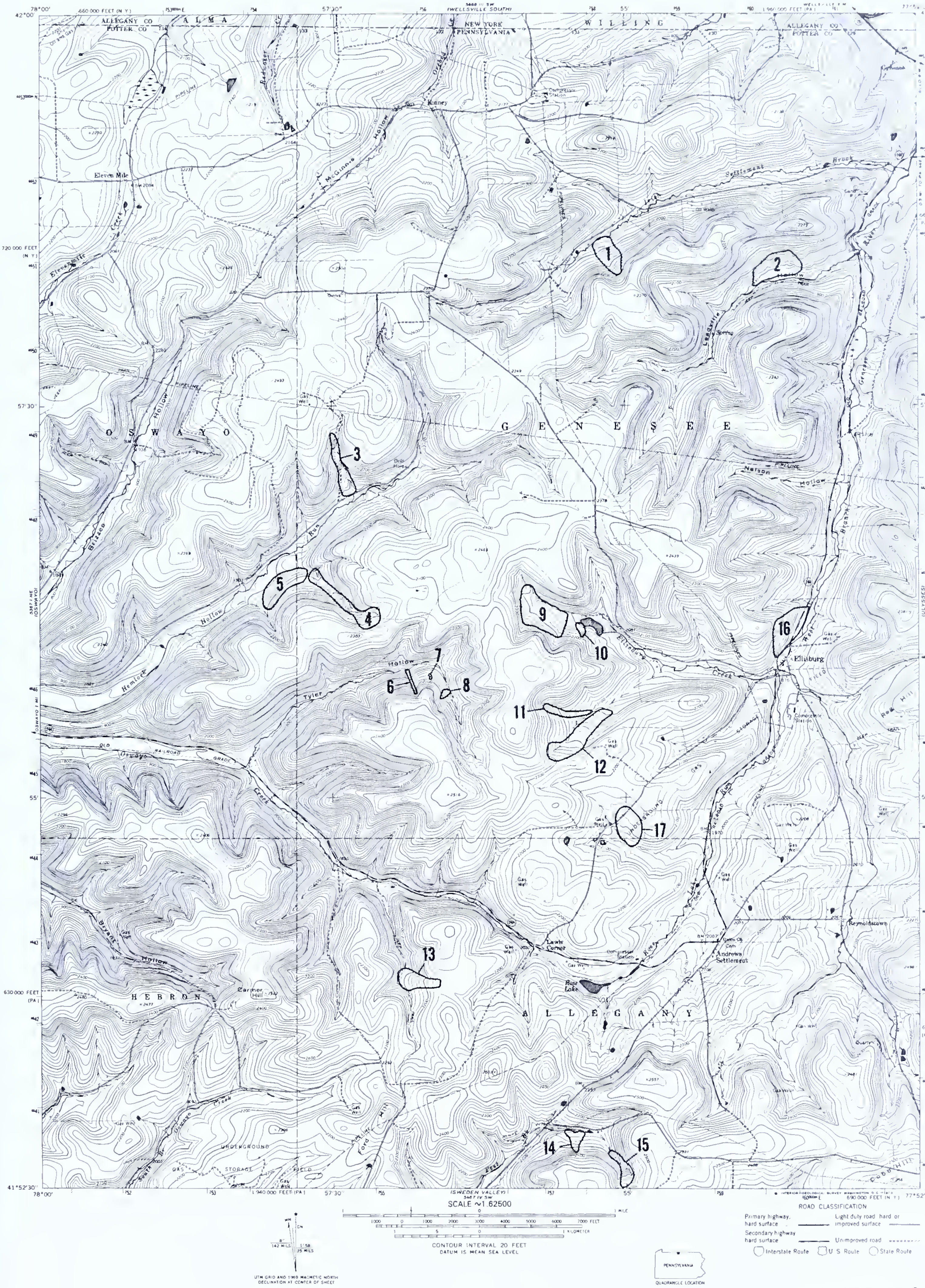
DUTCH MTN

Springfield
Harkness
Ayers Crossroads
East Smithfield
Wetona
Pine Lake
Leona
Mt Pisgah
Bourne Mills
East Troy
West Burlington
S P R I N G F I E L D
S M I T H F I E L D
W E S T
B U R L I N G T O N
T R O Y
SUGAR CREEK
1
2
3
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy duty
Light duty
Medium duty
U.S. Route
PENNSYLVANIA
QUADRANGLE LOCATION

EAST TROY


NEW YORK
PENNSYLVANIA
STEUBEN CO
TIOGA CO
Elkland
Osceola
Nelson
O S C E O L A
E L K L A N D
N E L S O N
D E E R F I E L D
F A R M I N G T O N
C H A T H A M
M I D D L E B U R Y
COWANESQUE
RIVER
Briar Hill
Farmington
Elbridge
Shingletown
1
2
3
4
5
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

ELKLAND


ALLEGANY CO
POTTER CO
ALMA
NEW YORK
PENNSYLVANIA
WILLING
Kinney
Eleven Mile
OSWAYO
GENESEE
HEBRON
ALLEGANY
Ellisburg
Reynoldstown
Andrews Settlement
Lewis Corner
Rose Lake
Carmer Hill
UNDERGROUND GAS STORAGE FIELD
1
2
3
4
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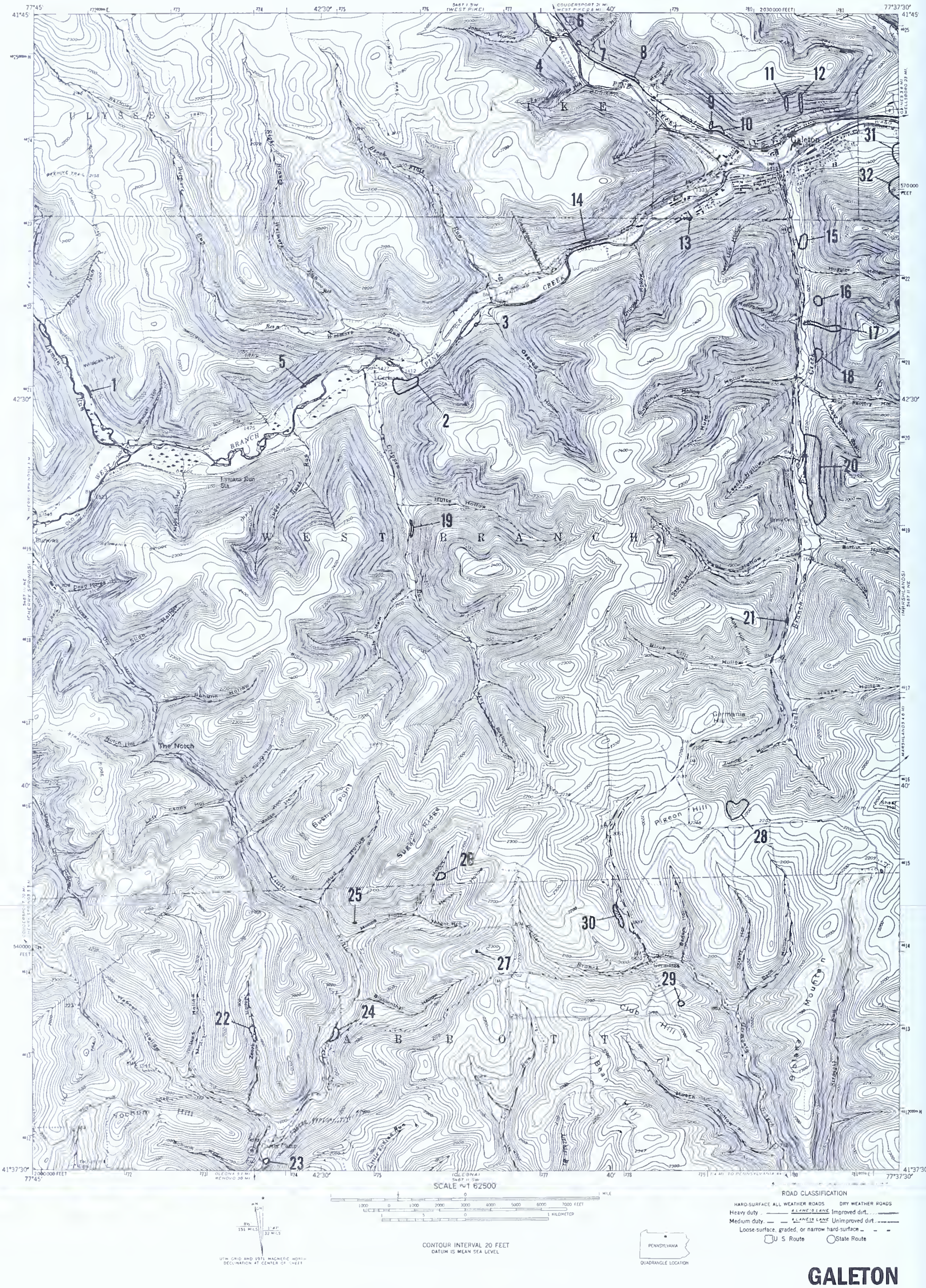
7
8
9
10
11
12
13
14
15
16
17
SCALE ~1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION

ELLISBURG

FARRANDSVILLE

FRIENDSVILLE



77°45'
41°45'
77°37'30"
41°37'30"
42'30"
40'
Galeton
The Notch
Pigeon Hill
Germania Hill
Lymans Run Sta
PIKE
ULYSSES
WEST BRANCH
ABBOTT
PINE CREEK
Club Hill
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
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21
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24
25
26
27
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29
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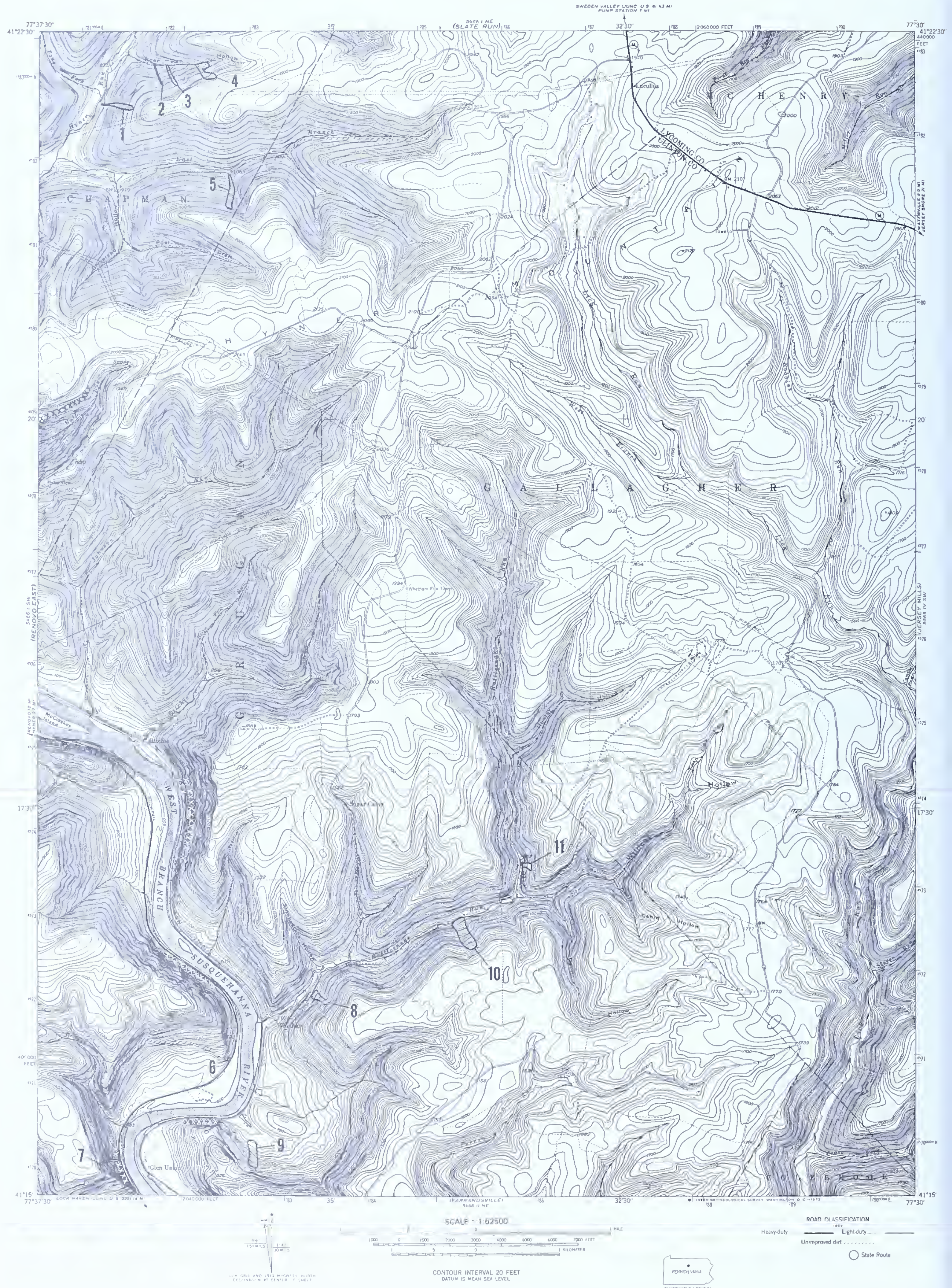
31
32
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy duty
Medium duty
Improved dirt
Unimproved dirt
U. S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

GALETON


SULLIVAN
TIOGA STATE FOREST
WARD
ARMENIA
UNION
ARMENIA MOUNTAIN
McIntosh Hollow
Fall Brook
Gleason
Tioga
County Bridge Picnic Area
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Primary highway hard surface
Light duty road, hard or improved surface
Secondary highway hard surface
Unimproved road
Interstate Route
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

GLEASON

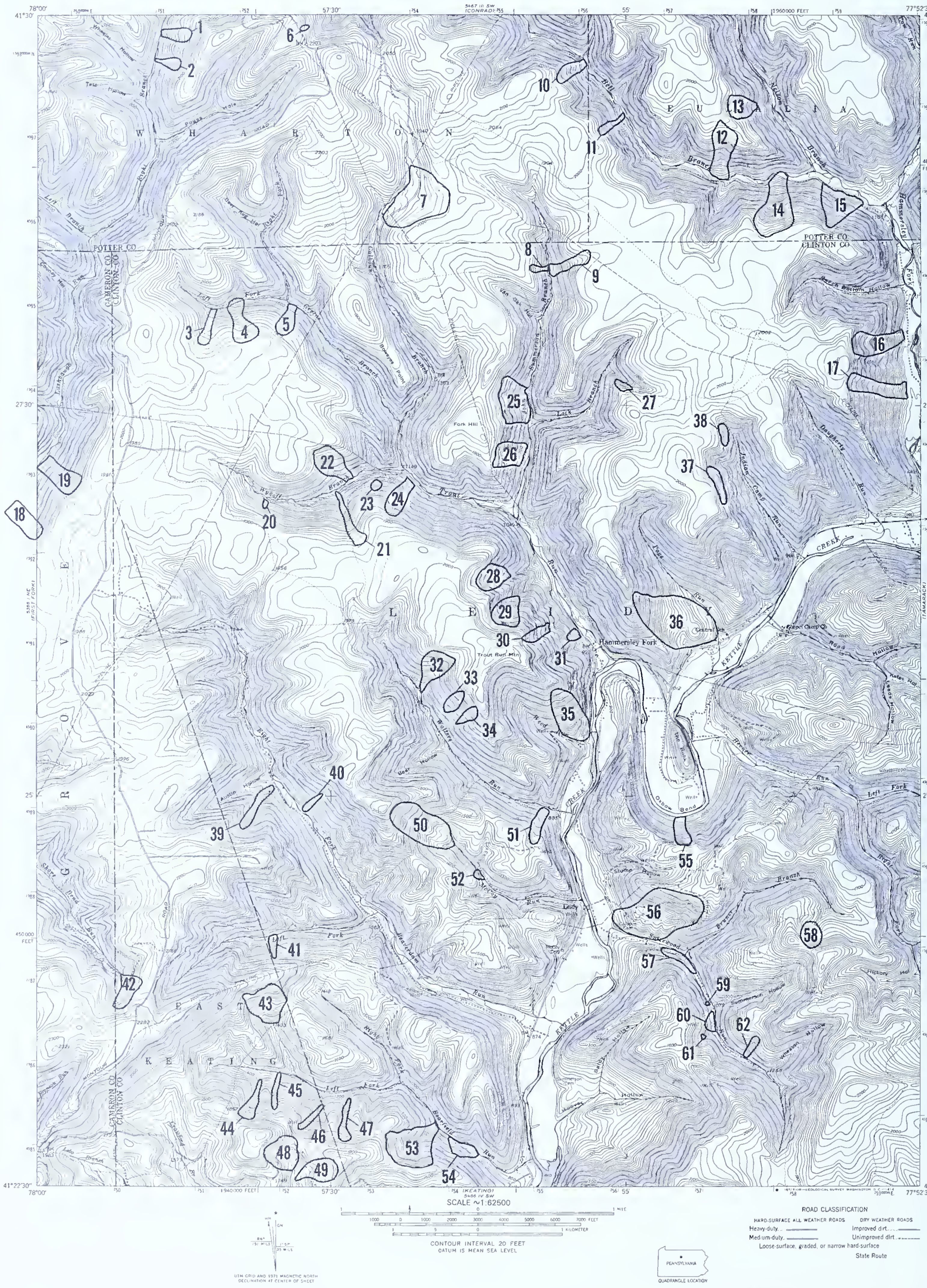


CHAPMAN
MCHENRY
GALLAGHER
WEST BRANCH SUSQUEHANNA RIVER
Glen Union
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Unimproved dirt
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

GLEN UNION


CANTON
LEROY
Grover
Chemung
BRADFORD CO
LYCOMING CO
SULLIVAN CO
STATE GAME LANDS NO 12
Schrader
Yorktown
Wheelerville
TIADAGHTON STATE FOREST
Davis Elbow
Maple Summit
McNETT
Ellenton
Tompkins Corners
FOX
MC INTYRE
CASCADE
WYOMING STATE FOREST
Rock Run
Towanda Creek
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1969 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

GROVER



HAMMERSLEY FORK

HARRISON VALLEY

HARVEYS LAKE


FOX
ELKLAND
WYOMING STATE FOREST
FORKS
HILLSGROVE
STATE GAME LANDS NO 134
SHREWSBURY
TIADAGHTON STATE FOREST
PLUNKETTS CREEK
SULLIVAN CO
LYCOMING CO
Bear Mtn
Big Hill
Gooseberry Hill
Round Top
Hillsgrove
Camp Mtn
Ogdonia
High Knob
Nettle Ridge
Rough Hill
Hunters Lake
LOYALSOCK CREEK
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION

HILLSGROVE

BEECH CREEK
SPROUL STATE FOREST
1
2
3
4
5
6
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9
10
11
12
13
14
15
16
17
21
Monument
Orviston
CLINTON CO
CENTRE CO
CURTIN
LIBERTY
Romola
Big Run
HOWARD
Howard
Wood
MARION
BOGGS
BALD EAGLE MTN
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
PENNSYLVANIA
QUADRANGLE LOCATION

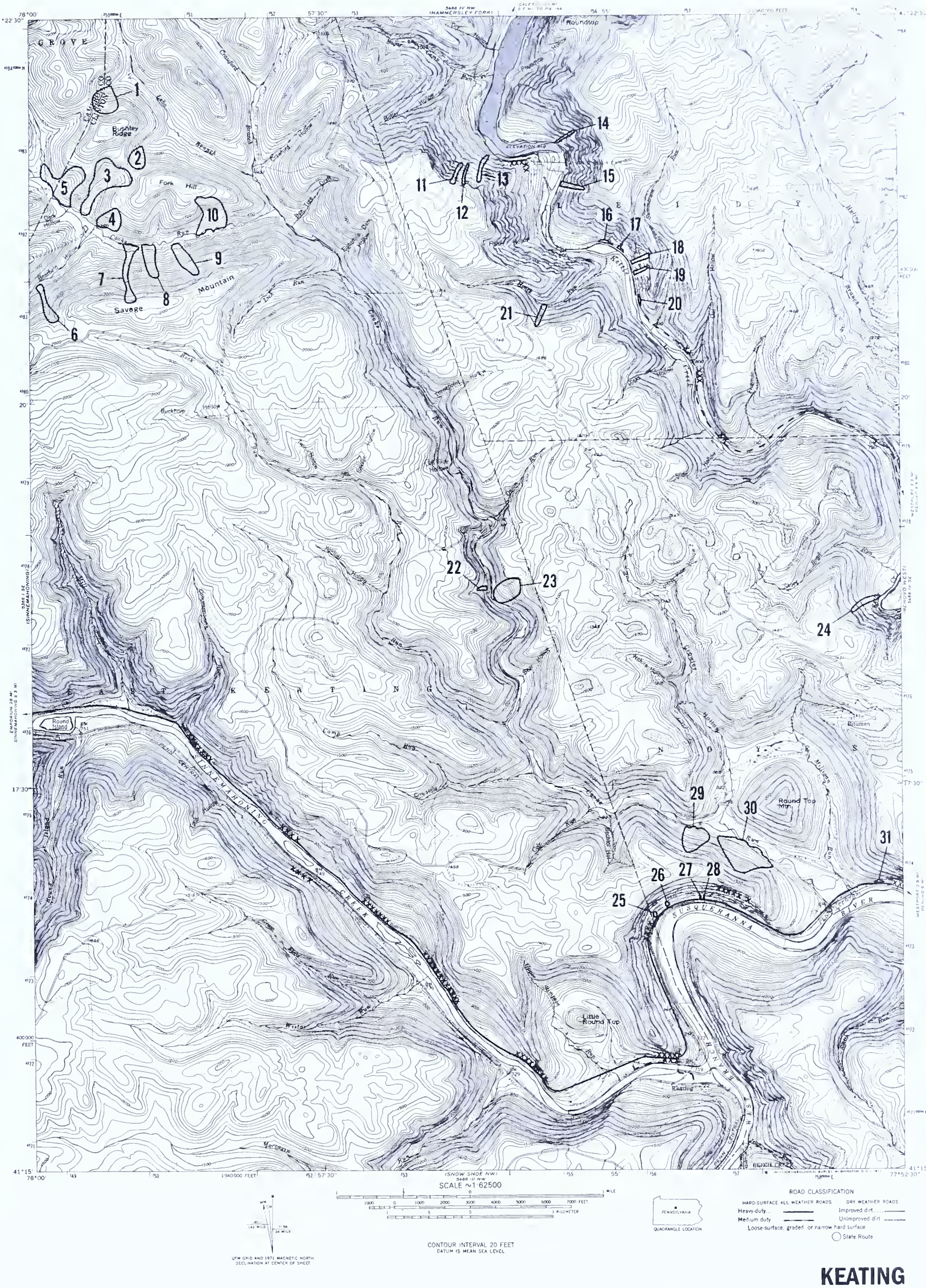
HOWARD

HUGHESVILLE

HUNTERSVILLE

JACKSON SUMMIT

JERSEY SHORE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31
Fork Hill
Savage
Mountain
Round Top Mtn.
Little Round Top
Round Island
Keating
SUSQUEHANNA
RIVER
SINNEMAHONING
CREEK
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
PENNSYLVANIA
QUADRANGLE LOCATION
State Route

KEATING

KEENEYVILLE


NEW YORK
PENNSYLVANIA
STEUBEN CO
TIOGA CO
Holden Creek
Bulkley
O S C E O L A
Redhouse Run
Biscuit Hollow
Wood Hollow
Abbott Hollow
Troups
Troups Creek
Wheaton Hollow
Moffit Hollow
APPROXIMATE BOUNDARY
B R O O K F I E L D
Rose Valley
Fork Hill
Knoxville
BOROUGH
Academy Corners
COWANESQUE RIVER
PENN CENTRAL
BALTIMORE AND OHIO
D E E R F I E L D
Yarnell Brook
Bowman Brook
Phillips
Cowanesque
W E S T F I E L D
Jemison Creek
Jemison Valley
C H A T H A M
Crooked Creek
Little Marsh
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

KNOXVILLE

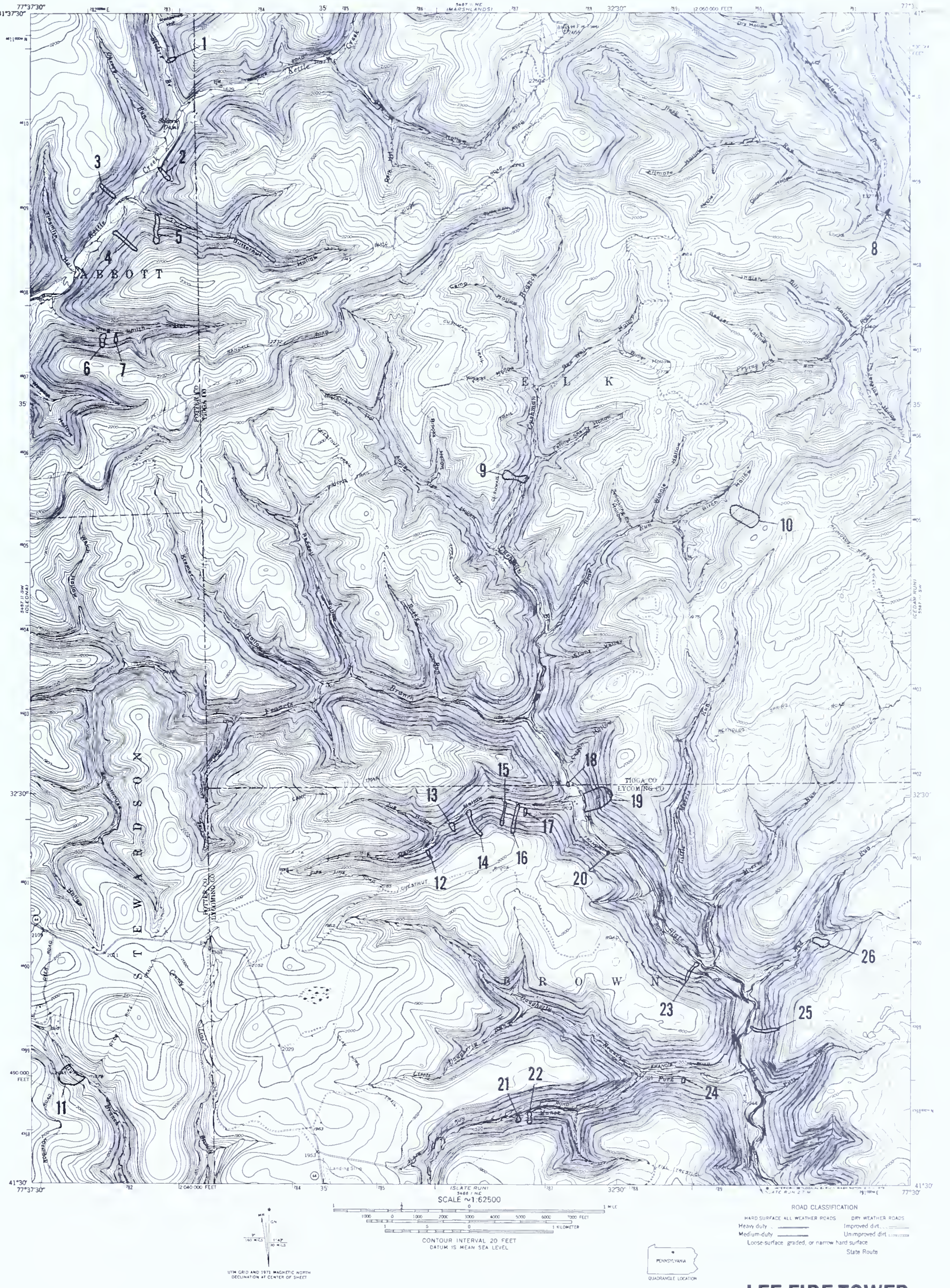
SUSQUEHANNA
RIVER
Laceyville
Browntown
Sugar Run
Rocky Forest
Spring Hill
Snyder Swamp
BRADFORD CO
WYOMING CO
T U S C A R O R A
B R A I N T R I M
W I L M O T
W I N D H A M
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy duty
Medium duty
Light duty
Unimproved dirt
U.S. Route
State Route
QUADRANGLE LOCATION

LACEYVILLE

LAIRDSVILLE

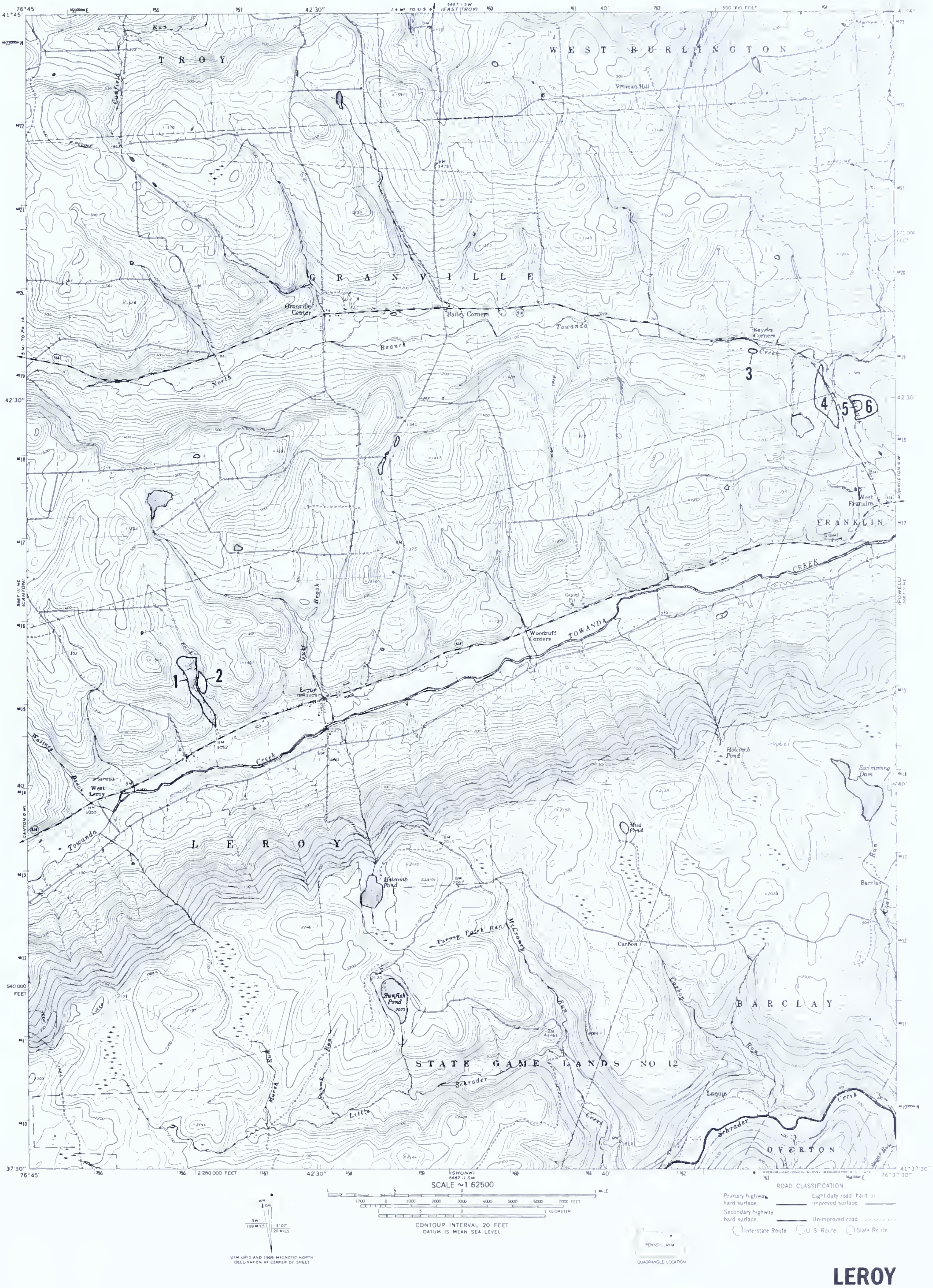

76°07'30"
41°52'30"
76°00'
41°52'30"
41°45'
76°07'30"
41°45'
76°00'
47'30"
50'
M I D D L E T O W N
F O R E S T L A K E
R U S H
Lawton
Rushville
Birchardville
Parks Crossroad
St Patricks Ch
Bagley Pond
North Branch
Middle Branch
East Branch
Wyalusing Creek
Wolf Creek
Fowler Hill
Stream
1
2
3
4
5
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Primary highway, all weather, hard surface
Light-duty road, all weather, improved surface
Secondary highway, all weather, hard surface
Unimproved road, fair or dry weather
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

LAWTON



LEE FIRE TOWER

LE RAYSVILLE


T R O Y
W E S T B U R L I N G T O N
Vroman Hill
G R A N V I L L E
Granville Center
Bailey Corners
Towanda
North
Branch
Creek
1
2
3
4
5
6
West Franklin
F R A N K L I N
Woodruff Corners
TOWANDA
CREEK
Leroy
West Leroy
Holcomb Pond
Swimming Dam
Mud Pond
L E R O Y
Barclay
Carbon
Turnip Patch Run
McCreary
Sunfish Pond
B A R C L A Y
STATE GAME LANDS NO 12
Schrader
Little
Laquin
OVERTON
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Primary highway, hard surface
Light duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U.S. Route
State Route
QUADRANGLE LOCATION

LEROY

TIOGA STATE FOREST
BRIER MOUNTAIN
LIBERTY
Sebring
East Point
Liberty
Jew Hill
TIOGA CO
LYCOMING CO
Hickory Knob
JACKSON
LAUREL
HILL
TIADAGHTON STATE FOREST
MCINTYRE
The Lakes
Long Ridge
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21
22
23
24
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U S Route
State Route
UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
PENNSYLVANIA
QUADRANGLE LOCATION

LIBERTY


M I F F L I N
W O O D W A R D
P I A T T
Larryville
Linden
Arrys Creek
PENN CENTRAL
WEST BRANCH SUSQUEHANNA RIVER
Cape Island
Jersey Shore Airport
Level Corner
Long Island
Antes Fort
Fort Antes
PORTER
N I P P E N O S E
S U S Q U E H A N N A
B A L D E A G L E M O U N T A I N
B A S T R E S S
Bastress
TIADAGHTON STATE FOREST
Mosquito Valley Run
L I M E S T O N E
Oval
Collomsville
N I P P E N O S E V A L L E Y
Oriole
LYCOMING CO
CLINTON CO
CRAWFORD
Rauchtown
1
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21
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION

LINDEN


WATSON
TIADAGHTON STATE FOREST
GALLAGHER
SPROUL STATE FOREST
Cole Hill
COLEBROOK
PINE CREEK
Woolrich
WOODWARD
DUNNSTABLE
Queens Run
Swissdale
Simcox Mountain
6
7
5
WEST BRANCH
SUSQUEHANNA RIVER
Great Island
Dunnstown
Lockport
LOCK HAVEN
Flemington
CASTANEA
Castanea
WAYNE
BALD EAGLE STATE FOREST
BALD EAGLE MTN
BALD EAGLE
ALLISON
8
9
10
1
2
3
4
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929
UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

LOCK HAVEN


T I O G A
R I C H M O N D
R U T L A N D
C O V I N G T O N
STATE GAME LANDS NO 37
Mansfield
Oak Hill
Austin Hill
Packing Hill
Kellytown
Lambs Creek
Lawrence Corners
Painter Run
Canoe Camp
Trailer Park
Hemlock Hill
TIOGA RIVER
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
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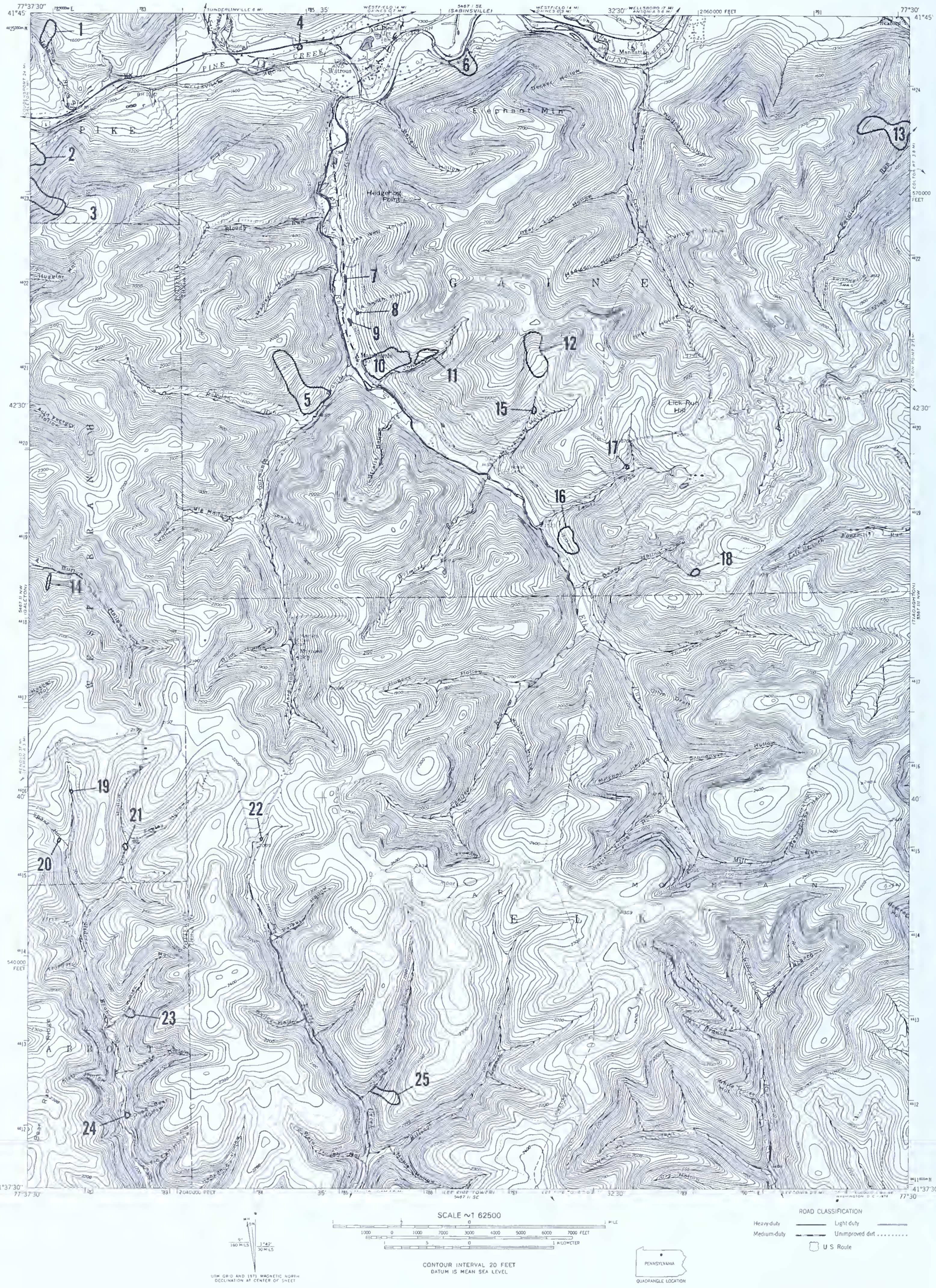
MANSFIELD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21
22
23
24
25
PINE CREEK
P I K E
G A I N E S
E L K
M O U N T A I N
Elephant Mtn
Hedgehog Pond
Lick Run Hill
Watrous
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light duty
Medium-duty
Unimproved dirt
U S Route
PENNSYLVANIA
QUADRANGLE LOCATION

MARSHLANDS


M E S H O P P E N
W A S H I N G T O N
M E H O O P A N Y
F O R K S T O N
SUSQUEHANNA
RIVER
Meshoppen
Meshoppen Creek
Blue Ridge Mtn
JAYNE BEND
Myobeach
Scottsville
North Mehoopany
Mehoopany Sta
Mehoopany
Mehoopany Creek
Little Mehoopany
Little Round Top
Fox Hollow Ch
Cedar Hill
Maynard Hill
Places Pond
Dorn Blaser Pond
Florey Knob
Russell Hill
Russell Hill Sch
Tunkel Hole
Rogers Hollow
Bowman Hollow
Forkston
Mehoopany Mountain
Doll Mountain
FORKSTON MOUNTAIN
MEHOOPANY FIRE TOWER
Sugar Hollow Creek
Jayne Pond
1
2
3
4
5
6
7
8
Mapped by the Geological Survey
1945
SCALE 1:62500
Contour interval 20 feet
Datum is mean sea level
ROAD CLASSIFICATION
Heavy-duty
Medium-duty
Light-duty
Unimproved dirt
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

MESHOPPEN


FISHINGCREEK
HUNTINGTON MOUNTAIN
LEE MOUNTAIN
KNOB MOUNTAIN
ORANGE
BRIARCREEK
NORTH CENTRE
SOUTH CENTRE
MIFFLIN
MAIN
SUSQUEHANNA RIVER
Pealertown
Evansville
Summer Hill
Berwick Heights
Martzville
Fowlersville
Dennis Mills
Old Stone
Briar Creek
BERWICK
Willow Springs
Mifflinville (Cressy Sta)
Lime Ridge
Hetlerville
1
2
3
SCALE ~1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U.S. Route
State Route
Interstate Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
MIFFLINVILLE


NEW YORK
PENNSYLVANIA
STEUBEN CO CHEMUNG CO
TIOGA CO
CHEMUNG CO
BRADFORD CO
Millerton
Norway Hill
Township Sch
West Jackson Ch
Alder
Hammond
Mosherville
Trowbridge
J A C K S O N
Bear Creek
Seeley Creek
Daggett
Beckwith
W E L L S
Jackson Center
Jobs Corners
Judson Hill
Buck Mtn
Saxtons Knob
R U T L A N D
C O L U M B I A
BRADFORD CO
TIOGA CO
Sopertown
1
2
3
4
5
6
7
8
9
10
11
12
13
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy duty
Light duty
Medium duty
Unimproved dirt
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

MILLERTON


STATE GAME LANDS
NO 226
Millville
GREENWOOD
ANTHONY
Jerseytown
MADISON
MOUNT PLEASANT
Derry
DERRY
Columbia Hill
WEST HEMLOCK
HEMLOCK
Buckhorn
VALLEY
FROSTY
VALLEY
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

MILLVILLE


Watsontown
Turbotville
McEwensville
New Columbia
Milton
West Milton
Central Oak Heights
North Hills
Springtown
Dewart
Warrior Run
White Deer
D E L A W A R E
L E W I S
T U R B O T
W H I T E D E E R
L I M E S T O N E
LIMESTONE RIDGE
L I B E R T Y
EAST CHILLISQUAQUE
WEST CHILLISQUAQUE
WEST BRANCH SUSQUEHANNA RIVER
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
MILTON


South Towanda
SUSQUEHANNA
TOWANDA
VALLEY
FLATS
TOWANDA CREEK
Tip Top
Hale Mtn
Ulster
Monroeton
Liberty Corners
ASYLUM
Marcy Point
TIOGA STATE FOREST
Round Top
Kellogg
MOUNTAIN
STATE GAME LANDS NO 36
MONROE
STATE GAME LANDS NO 240
Nichols Point
ROBWOOD MTN
KELLOGG
South Branch
ALBANY
TERRY
Hatch Mtn
Marshview
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
1
2
3

MONROETON

MONTOURSVILLE NORTH

MONTOURSVILLE SOUTH


STATE GAME LANDS
NO 268
D U N C A N
Bald Hill
Babb Creek
F O R E S T
Hickory Ridge
STATE
Morris
Hoytville
Blacks Hill
Plank Hill
T I O G A
Tannery Hill
M O R R I S
Fork Hill
The Horn
Doane
Brooks Hill
Three Springs Run
Mt Pleasant
TIOGA STATE FOREST
TIOGA
STATE FOREST
Tioga Co
Lycoming Co
Lorenton
TIOGA CO
LYCOMING CO
Texas Mountain
Oregon Hill
P I N E
Trout Run
STATE GAME LANDS
NO 75
1
2
3
4
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
U.S. Route
State Route
QUADRANGLE LOCATION

MORRIS


FAIRFIELD
MUNCY
WOLF
King Island
The Gut
WEST BRANCH SUSQUEHANNA RIVER
TIADAGHTON STATE FOREST
BALD EAGLE MOUNTAIN
1
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CLINTON
STATE CORRECTIONAL INSTITUTION
Muncy
MUNCY CREEK
HILLS
Montgomery
LYCOMING CO
NORTHUMBERLAND CO
DELAWARE
LEWIS
Pennsdale
Chippewa
Halls
Sagers
Delaware Run
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
UTM GRID AND 1988 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
Interstate Route
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

MUNCY


P L Y M O U T H
H U N L O C K
West Nanticoke
Hunlock Gardens
Hunlock
Hunlock Creek
SUSQUEHANNA
RIVER
DELAWARE AND HUDSON
CONRAIL
NANTICOKE
Honey Pot
SHICKSHINNY MOUNTAIN
UNION
Newport
Newport Center
Sheatown
Alden
Glen Lyon
N E W P O R T
Wanamie
St Vladimir Ch
Mountain
Fairchild Pond
Little Wilkes-Barre
Reservoir
Folstown
Mud Pond
Kielar Lake
Lee
Nojaka Pond
M O U N T A I N
P E N O B S C O T
Slocum Ch
Cranberry Pond
Slocum Corners
Lily Lake
S L O C U M
Mt Zion Union Ch
Slocum
Stairville
D O R R A N C E
Pond Hill
Turtle Creek
1
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3
4
5
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U.S. Route
State Route
QUADRANGLE LOCATION
UTM GRID AND 1976 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

NANTICOKE


TIOGA STATE FOREST
MORRIS
LIBERTY
PINE
JACKSON
Nauvoo
Hartfield
Plank
TIOGA CO
LYCOMING CO
Sugar Hill
Zimmerman
Creek
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

NAUVOO


(MESHOPPEN)
(HARVEYS LAKE)
(DUTCH MOUNTAIN)
(CENTER MORELAND)
F O R K S T O N
N O X E N
SCHOOLEY MOUNTAIN
1
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8
Evans Falls
Hettesheimer Corners
Childrens Welfare Center
Noxen
Stone Mtn
Bowman Creek
Grassy Ridge
Beechnut Ridge
Hickory Knob
Galkas Pond
Ruggles
Harveys Lake
WYOMING CO
LUZERNE CO
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
PENNSYLVANIA
QUADRANGLE LOCATION
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U S Route
State Route

NOXEN


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A B B O T T
S T E W A R D S O N
Hickory Ridge
Big Ridge
CREEK
OLE BULL STATE PARK
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
U. S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

OLEONA

PICTURE ROCKS

POTTER BROOK


WEST BURLINGTON
BURLINGTON
TOWANDA
FRANKLIN
Franklin Centre
Franklindale
Powell
Preacher
Brook
Highland
CREEK
TOWANDA
Naglee
Mountain
MONROE
Weston
Bull
Run
Lamoka Mtn
Mines
Cash Pond
Cash Mtn
Stone Mtn
STATE GAME LANDS NO 12
BARCLAY
STATE GAME LANDS NO 36
Long Valley
Run
SCHRADER
Barclay Station
OVERTON
Millstone
STATE GAME LANDS NO 36
Deep
Hollow
Chilson Run
Nettle Run
1
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16
17
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
PENNSYLVANIA
QUADRANGLE LOCATION

POWELL


Union Center
Ogdensburg
Spencer Town
U N I O N
Pemryn
Leolyn
Newelltown
Dogtown
TIOGA CO
LYCOMING CO
Roaring Branch
South Union
M C N E T T
Carry Swamp
T I A D A G H T O N
S T A T E F O R E S T
M C I N T Y R E
SULLIVAN MOUNTAIN
TIADAGHTON STATE FOREST
Ralston
1
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SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U. S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

RALSTON


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31
Renovo
South Renovo
SUMMERSON MOUNTAIN
HYNER MOUNTAIN
WEST BRANCH SUSQUEHANNA RIVER
Hyner
North Bend
Glen Union
SCALE ~1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION

RENOVO EAST


SPROUL STATE FOREST
Renovo
West Renovo
South Renovo
Drury Run
Westport
Shintown
SUSQUEHANNA
RIVER
WEST BRANCH
KETTLE CREEK
High Knob
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U.S. Route
State Route
QUADRANGLE LOCATION
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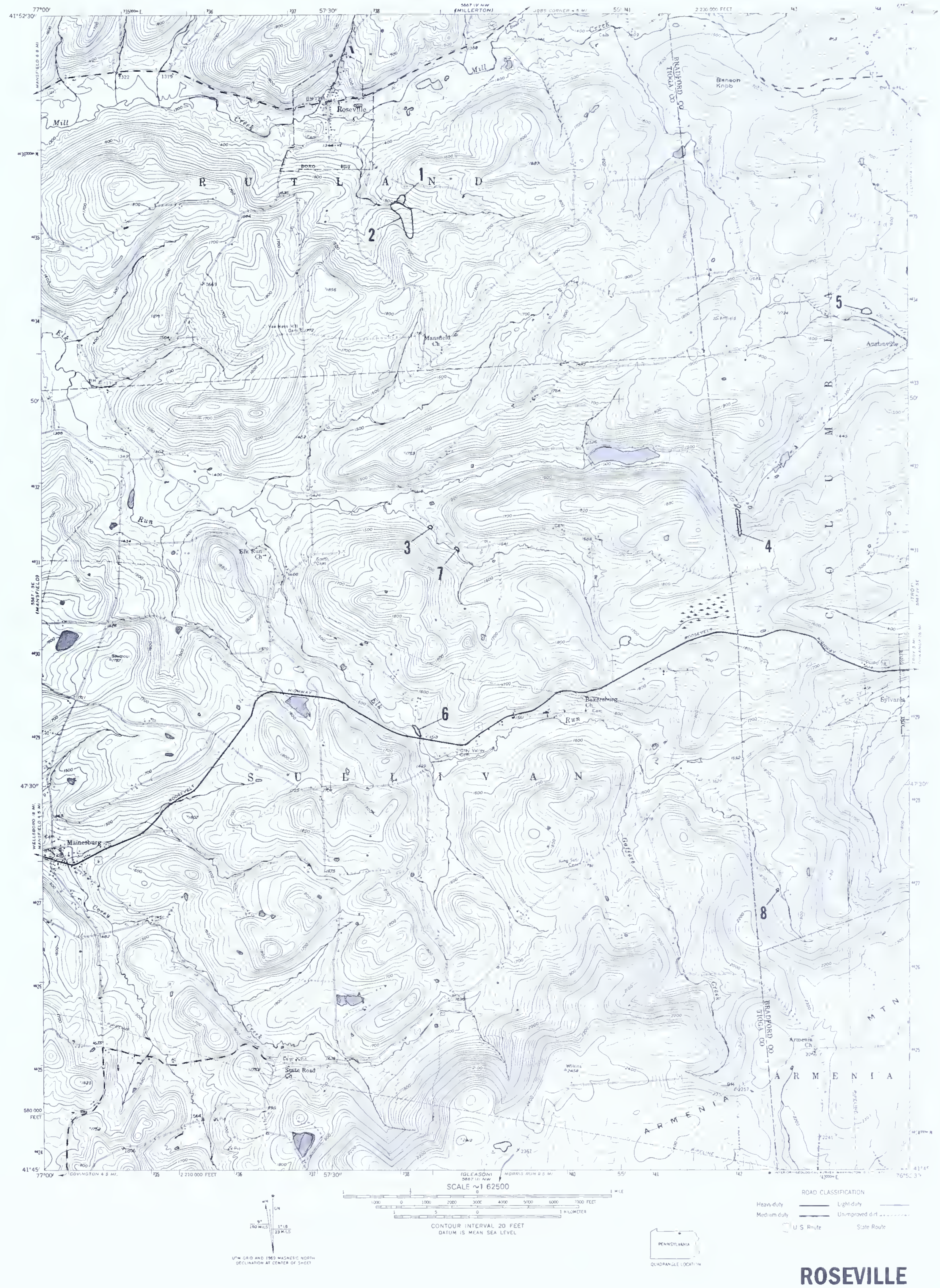
33

RENOVO WEST


RUTLAND
SULLIVAN
COLUMBIA
ARMENIA
Roseville
Mansfield Ch
Mainesburg
Elk Run
Mill Creek
Benson Knob
Austinville
Sylvania
Bungerburg Ch
State Road Ch
Armenia Ch
ARMENIA MTN
BRADFORD CO
TIOGA CO
1
2
3
4
5
6
7
8
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
PENNSYLVANIA
QUADRANGLE LOCATION

ROSEVILLE

SABINSVILLE


NEW YORK
PENNSYLVANIA
CHEMUNG CO.
BRADFORD CO.
TIOGA CO.
Chemung
Valley
CHEMUNG
RIVER
Spanish Hill
SAYRE
Milltown
CAYUTA CREEK
Chemung Valley Landing Strip
VALLEY
CHEMUNG
Athens
East Athens
SUSQUEHANNA
RIVER
A T H E N S
Paines Island
FLATS
Greenes Landing
ESTHER
QUEEN
Wolcott
Creek
STATE GAME LANDS NO. 239
Milan
SHESHEQUIN
Sheshequin
Balsam Pond
U L S T E R
S M I T H F I E L D
Ruffs Corner
Peas Hill
1
2
3
4
5
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Primary highway hard surface
Light-duty road, hard or improved surface
Secondary highway hard surface
Unimproved road
Interstate Route
U.S. Route
State Route
UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
PENNSYLVANIA
QUADRANGLE LOCATION

SAYRE

SHICKSHINNY

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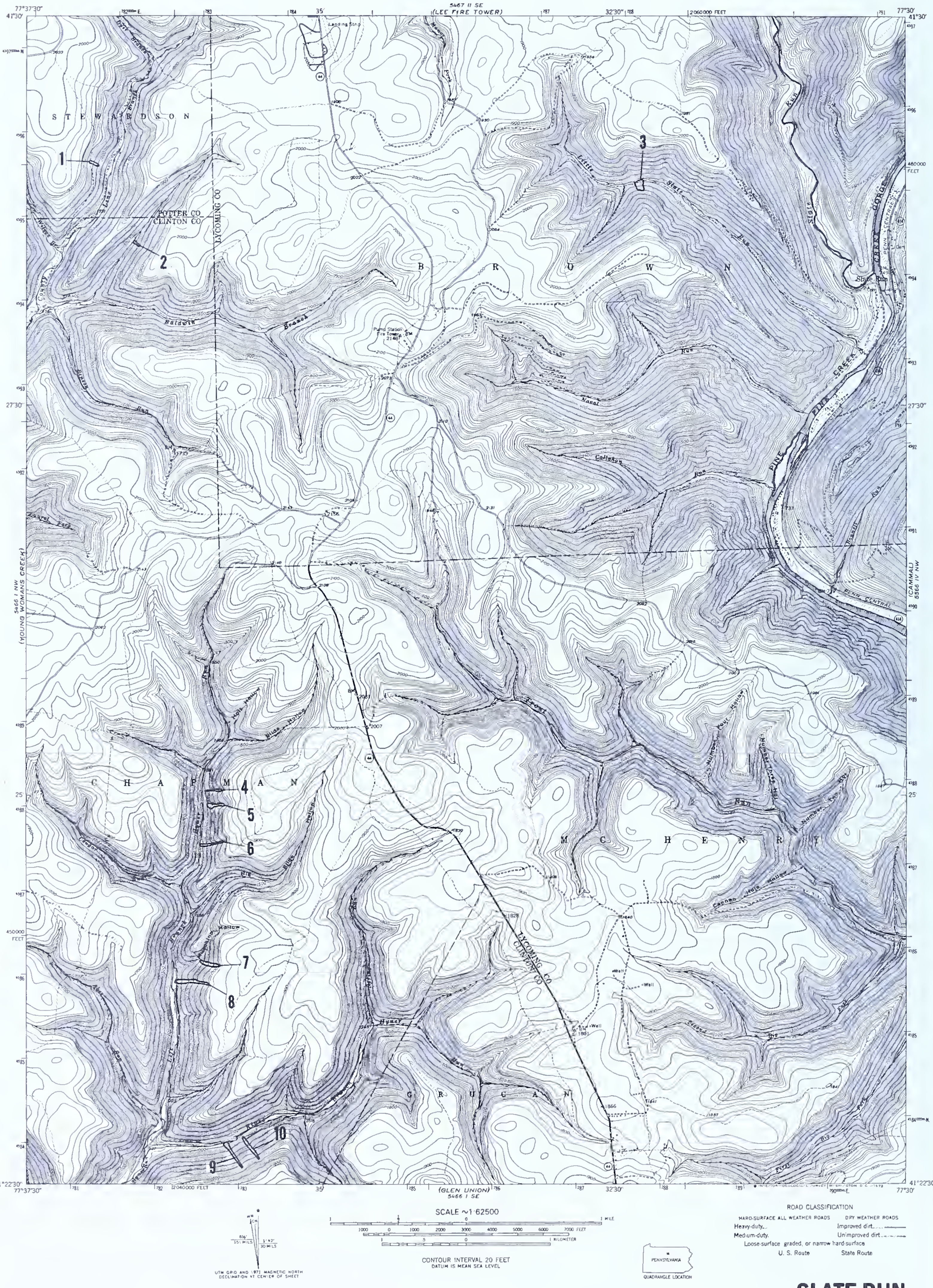
16
17
18
19
Pine Hill
A B B O T T
E U L A L I A
S T E W A R D S O N
Elk Lick Knob
Short Run
Dry Hollow
Cherry Run
Big Bench Hollow
Duke Run
Gravel Lick
Keeney Mtn
SCALE ~1 62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION

SHORT RUN


STEWARDSON
BROWN
CHAPMAN
MCHENRY
GRUGAN
POTTER CO.
CLINTON CO.
LYCOMING CO
CLINTON CO
PINE CREEK
Slate Run
1
2
3
4
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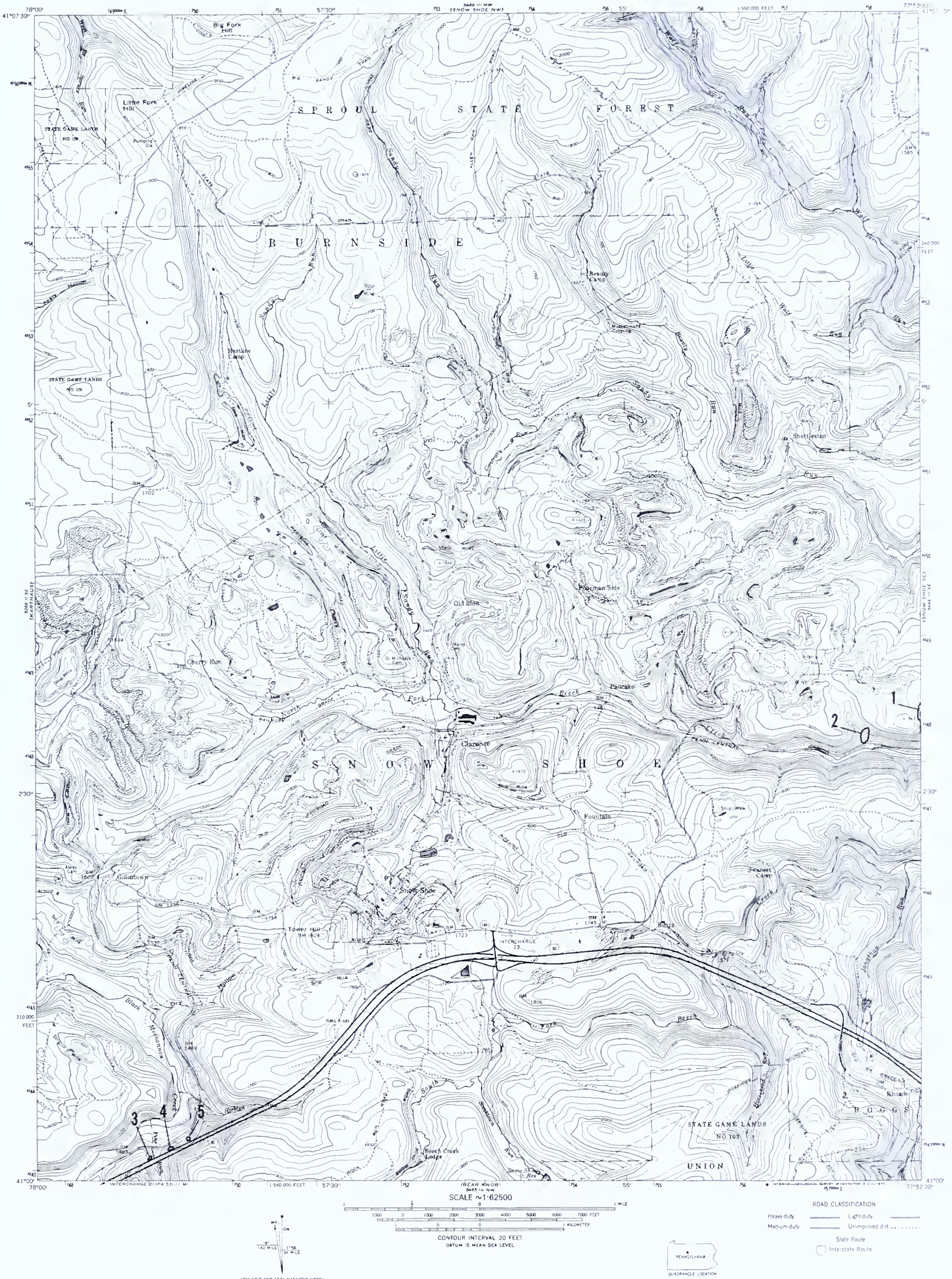
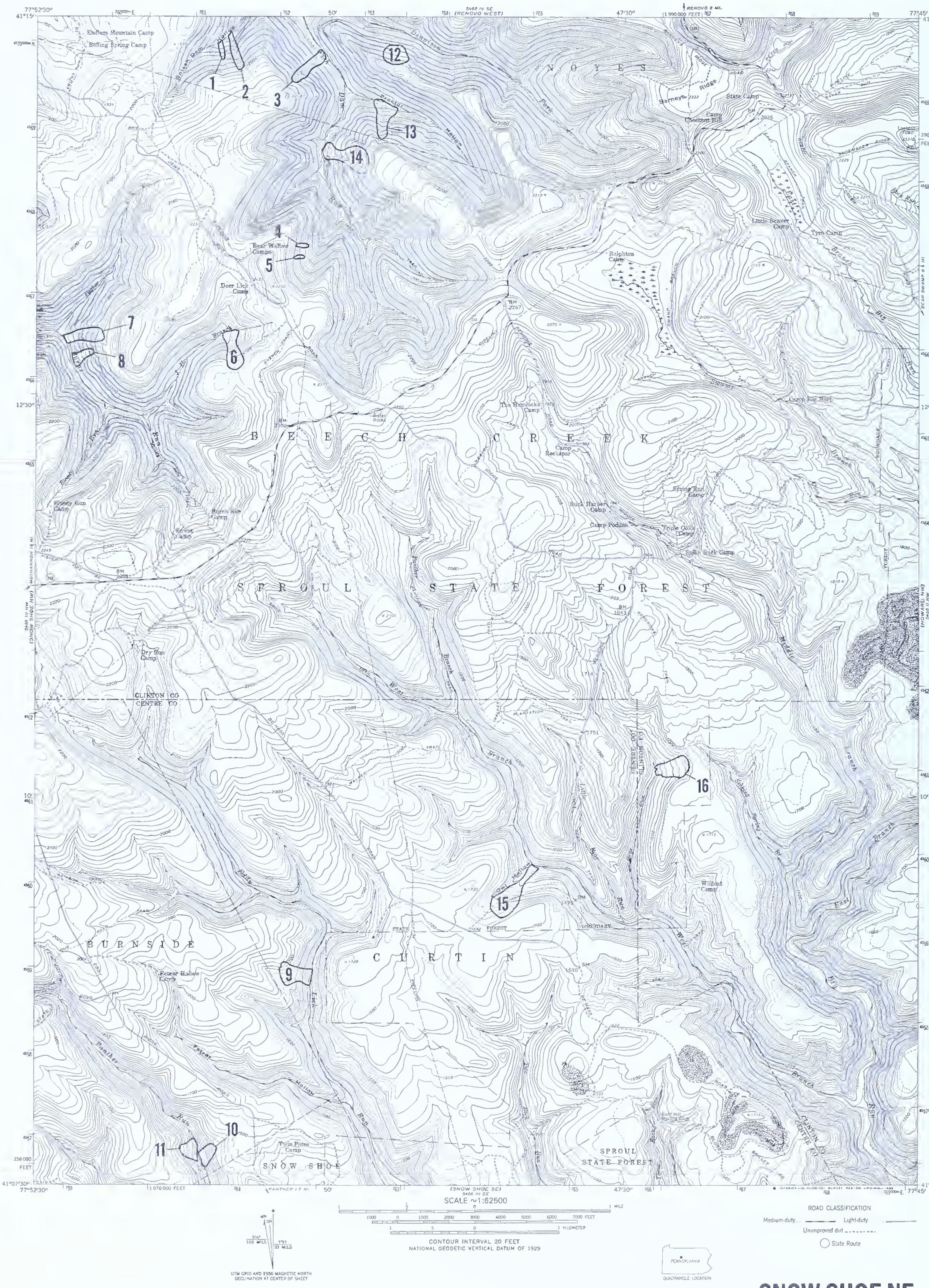
6
7
8
9
10
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
QUADRANGLE LOCATION
PENNSYLVANIA

SLATE RUN


S P R O U L S T A T E F O R E S T
B U R N S I D E
S N O W S H O E
Big Fork Hill
Little Fork Hill
STATE GAME LANDS NO 100
Pumping Sta
Beauty Camp
Hartline Camp
Shettleston
Old Slide
Cherry Run
Pancake
Clarence
Fountain
Gillintown
Snow Shoe
Tower Hill
Swanset Camp
Rhoads
B O G G S
STATE GAME LANDS NO 103
UNION
Beech Creek Lodge
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy duty
Light duty
Medium duty
Unimproved dirt
State Route
Interstate Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1971 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
SNOW SHOE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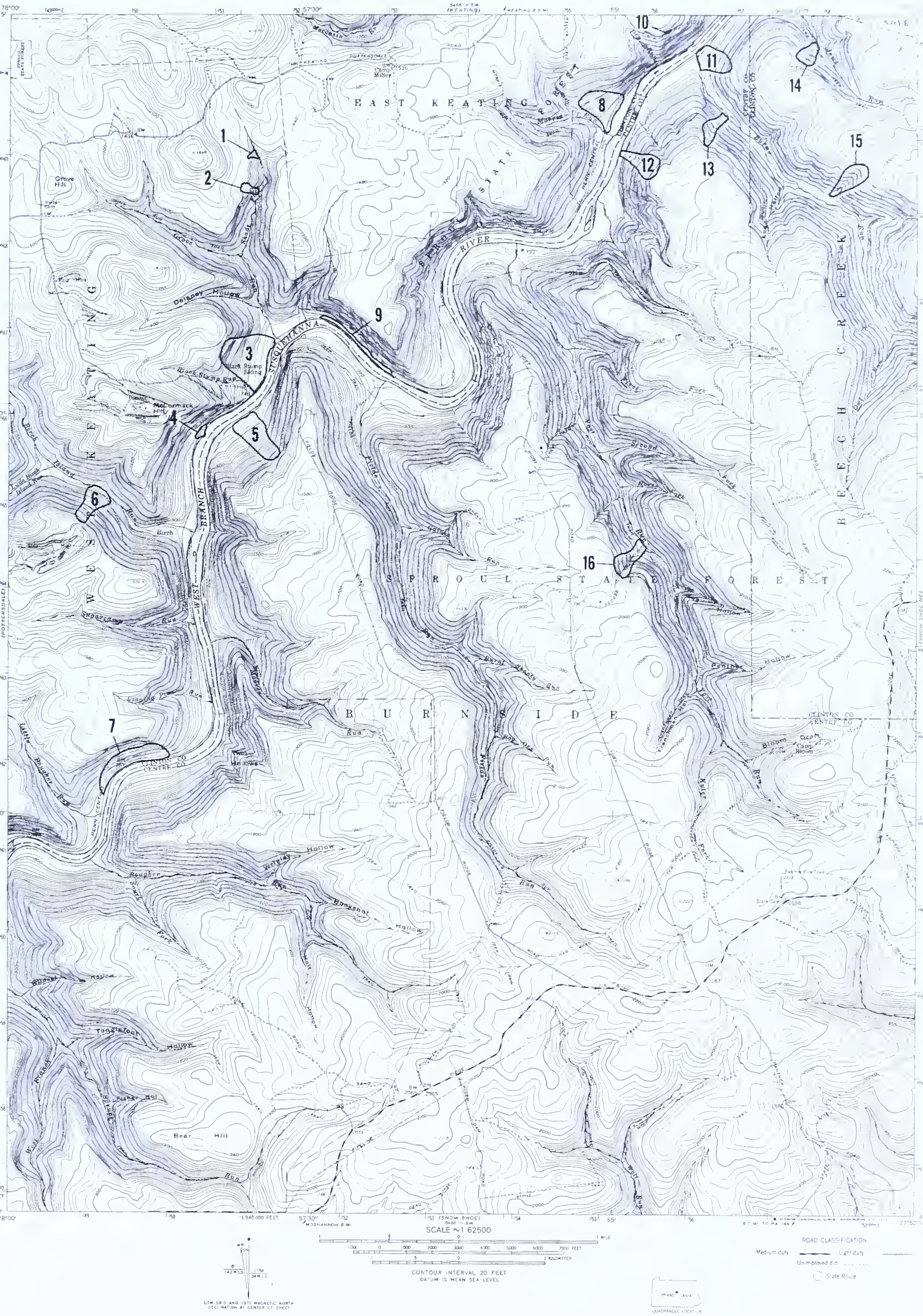
16
Endless Mountain Camp
Boiling Spring Camp
N O Y E S
Barney's Ridge
State Camp
Chestnut Hill
Little Beaver Camp
Tyro Camp
Bear Wallow Camps
Deer Lick Camp
Ralphton Camp
The Hemlocks Camp
Camp Rockspar
B E E C H   C R E E K
Spring Run Camp
Buck Harbor Camp
Camp Podunk
Triple Oaks Camp
Spike Buck Camp
Honey Run Camp
Burns Run Camp
S P R O U L   S T A T E   F O R E S T
Dry Run Camp
CLINTON CO
CENTRE CO
Wildcat Camp
B U R N S I D E
Fetzer Hollow Camp
C U R T I N
Twin Pines Camp
S N O W   S H O E
SPROUL STATE FOREST
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Medium-duty
Light-duty
Unimproved dirt
State Route
UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
PENNSYLVANIA
QUADRANGLE LOCATION

SNOW SHOE NE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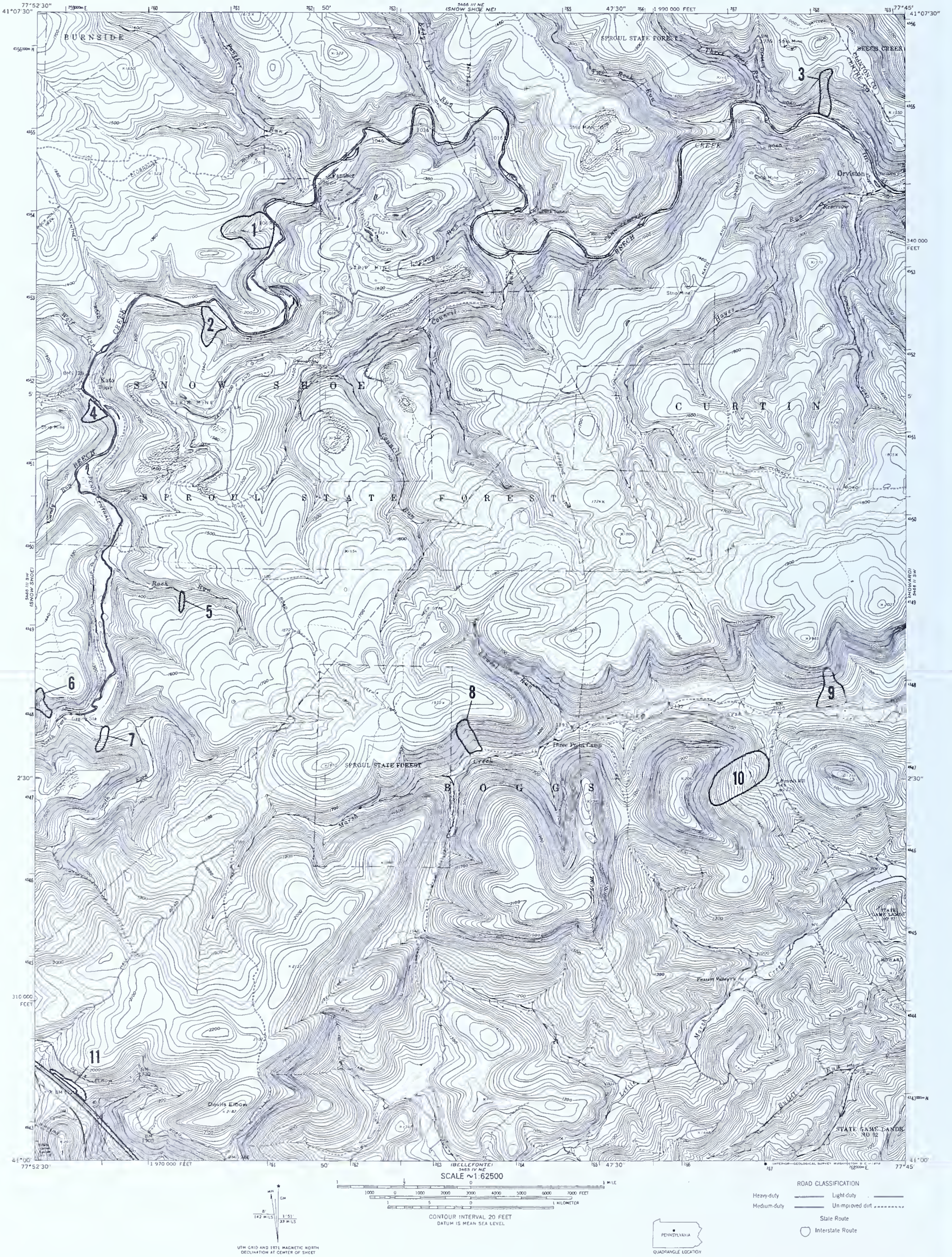
16
EAST KEATING
WEST KEATING
SPROUL STATE FOREST
BURNSIDE
BEECH CREEK
SUSQUEHANNA RIVER
WEST BRANCH
Grove Hill
Delaney Hollow
Black Stump Siding
McCormack Hill
Birch
Sugarcamp Run
Wrigley Hollow
Buckshot Hollow
Tanglefoot Hollow
Bear Hill
Camp Bloom
CLINTON CO
CENTRE CO
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION

SNOW SHOE NW



77°52'30"
41°07'30"
77°45'
41°00'
BURNSIDE
SNOW SHOE
CURTIN
SPROUL STATE FOREST
BOGGS
BEECH CREEK
Orviston
Three Point Camp
Devils Elbow
STATE GAME LANDS NO 92
1
2
3
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6
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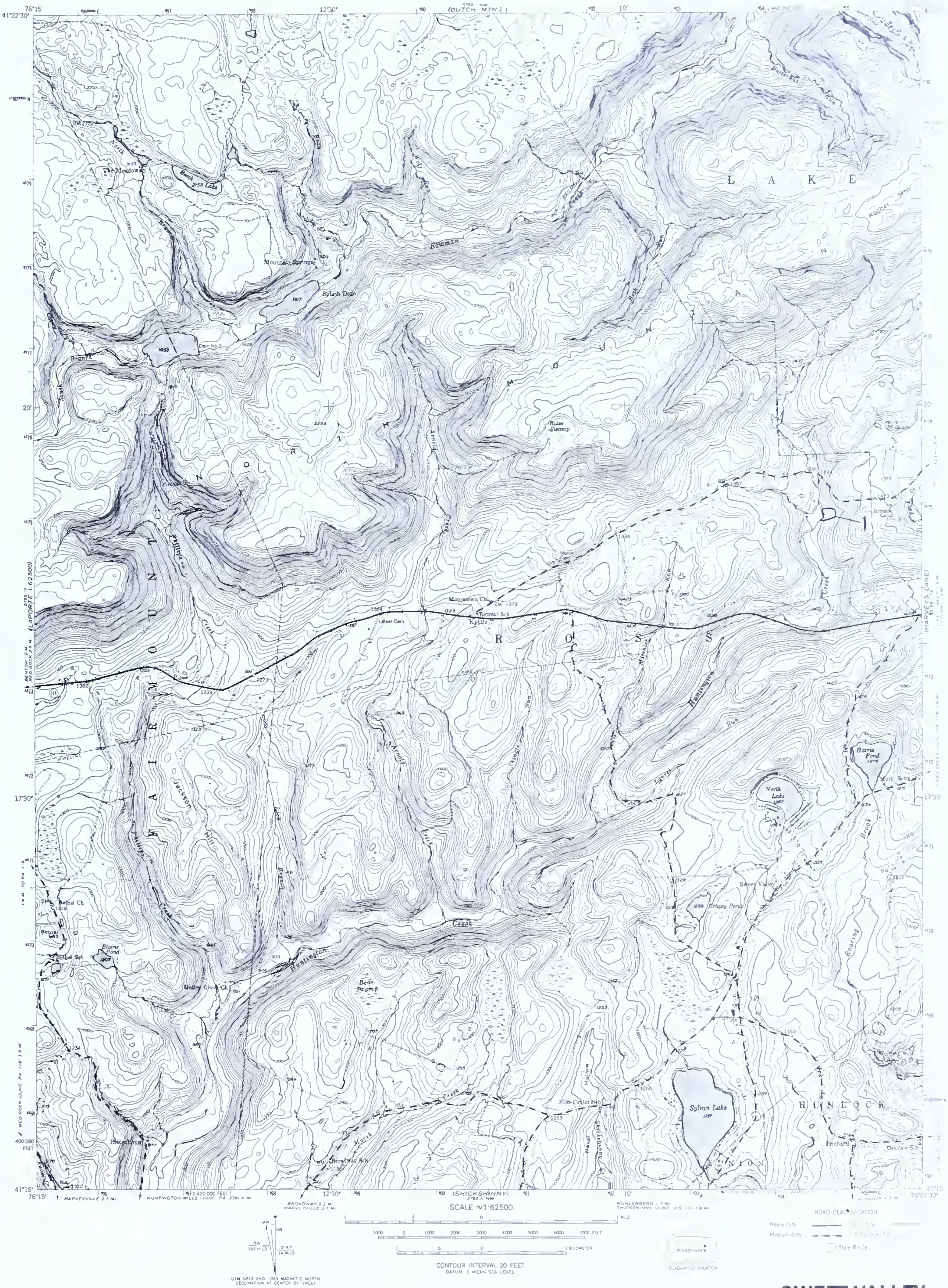
10
11
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
State Route
Interstate Route
PENNSYLVANIA
QUADRANGLE LOCATION

SNOW SHOE SE


SHREWSBURY
LAPORTE
DAVIDSON
NORTH MOUNTAIN
STATE GAME LANDS NO 13
HUCKLEBERRY MOUNTAIN
PENN
FRANKLIN
JORDAN
Sonestown
Muncy Valley
Beech Glen
Hemlock Grove
Strawbridge
Beaver Lake
North Mountain
Lungerville
SULLIVAN CO
LYCOMING CO
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION

SONESTOWN

SWEDEN VALLEY



SWEET VALLEY


77°52'30"
41°30'
77°45'
41°30'
Keeney Mountain
POTTER CO
CLINTON CO
KETTLE
CREEK
Dykes Peak
Turtle Point
Tamarack
Tamarack Swamp
Fork Hill
Ridge
1
2
3
4
5
6
7
8
9
27'30"
25'
41°22'30"
77°52'30"
41°22'30"
77°45'
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Medium-duty
Light-duty
Unimproved dirt
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
TAMARACK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MOUNT TOM
PINE CREEK
Barbour Rock
Sherman Sch
Middle Ridge
Thumptown
Kennedy
Red Ledge Ridge
Cobble Hill
Callahan Hill
S H I P P E N
D E L M A R
E L K
M O R R I S
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Medium-duty
Improved dirt
Unimproved dirt
Loose-surface or narrow hard surface
U. S. Route
State Route
QUADRANGLE LOCATION

TIADAGHTON


NEW YORK
PENNSYLVANIA
STEUBEN CO
TIOGA CO
Lawrenceville
RIVER
COWANESQUE
Lake
Tompkins
Nelson
N E L S O N
L A W R E N C E
F A R M I N G T O N
Farmington Hill
M I D D L E B U R Y
T I O G A
Brooklyn
Tioga
RESERVOIR
CROOKED HAMMOND
STATE GAME LANDS NO 37
Tioga
Reservoir
1
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14
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Heavy duty
Light duty
Medium duty
Unimproved dirt
U. S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
UTM GRID AND 1980 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
TIOGA

Sheshequin
Ghent
North Rome
ROME
SHESHEQUIN
Harnbrook
Quarry Glen
Bald Eagle Island
WYSOX
NORTH TOWANDA
North Towanda
Towanda
East Towanda
Wysox
Myersburg
Macedonia
ASYLUM
TOWANDA
SUSQUEHANNA RIVER
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
1 2 3 4 5 6 7 8 9 10

TOWANDA

JACKSON
MOUNTAIN
LAUREL
MC INTYRE
TIADAGHTON STATE FOREST
SUGARCAMP
MOUNTAIN
MIDDLE RIDGE
NARROW
MOUNTAIN
LEWIS
COGAN HOUSE
STATE GAME LANDS NO 133
GAMBLE
Trout Run
Fields Station
LYCOMING CREEK
PENN CENTRAL
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36
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38
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

TROUT RUN


SPRINGFIELD
COLUMBIA
Columbia Cross Roads
North Branch
Sugar Creek
Sylvania
Farmers Valley
Troy Reservoir
West Branch
Troy
Paine Hill
TROY
ARMENIA
ARMENIA MOUNTAIN
Tamarack Swamp
OAK HILL
Austinville
Alparon Park
Mud Creek
Fall Brook
1
2
3
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U.S. Route
State Route
QUADRANGLE LOCATION

TROY


SMITHFIELD
ULSTER
BURLINGTON
NORTH TOWANDA
TOWANDA
WEST BURLINGTON
SUSQUEHANNA RIVER
Sheshequin Valley
Ulster
Burlington
Browns Pond
Mountain Lake
Sugar Creek
1
2
SCALE ~1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
QUADRANGLE LOCATION

ULSTER


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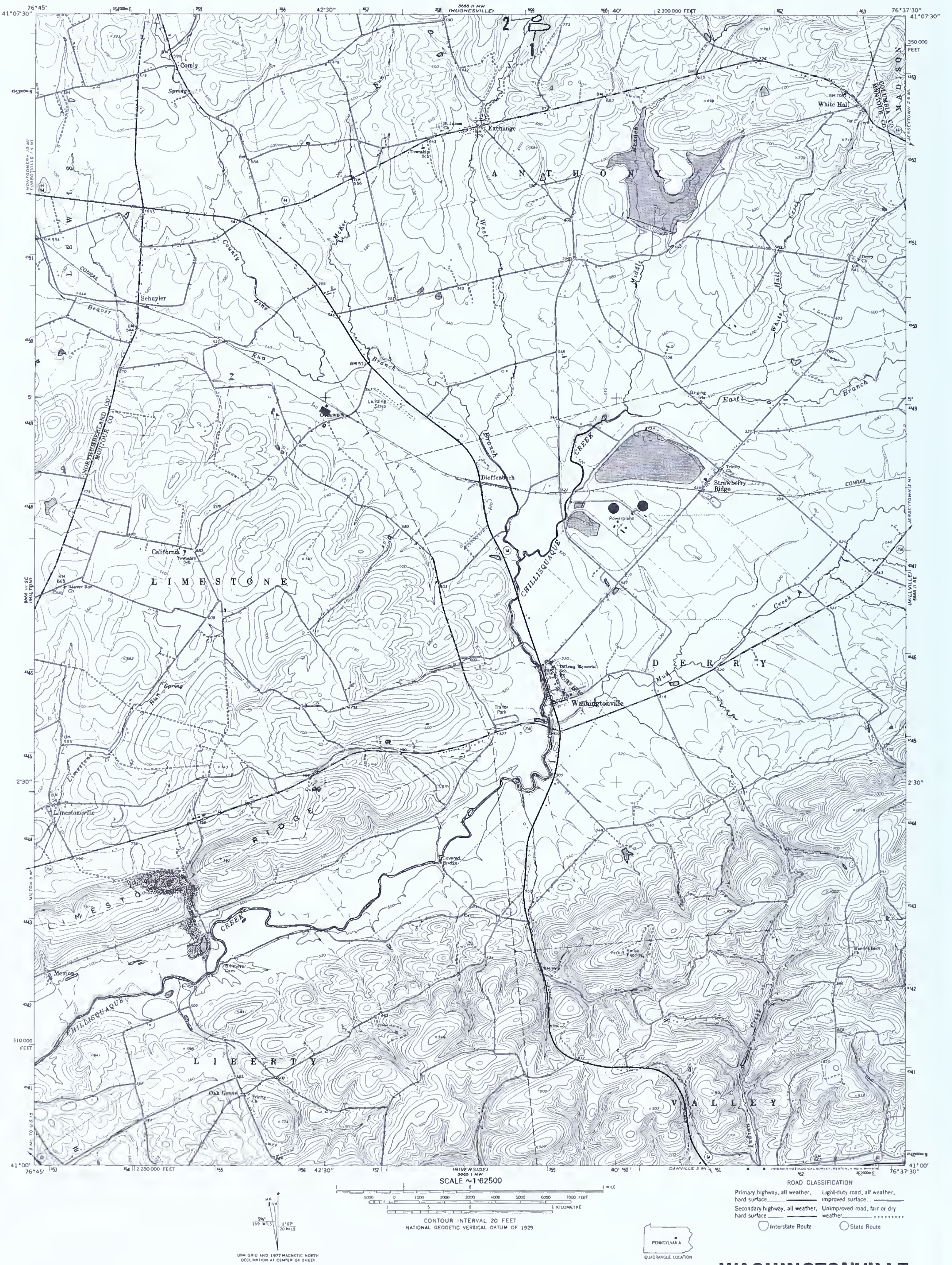
14
15
16
GENESEE
BINGHAM
ALLEGANY
ULYSSES
INDEPENDENCE
NEW YORK
PENNSYLVANIA
Genesee
Hickox
West Bingham
Bingham Center
North Bingham
Harmontown
Ulysses
Newfield
Kibbeville Corners
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Primary highway, hard surface
Light duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U. S. Route
State Route
QUADRANGLE LOCATION

ULYSSES



WASHINGTONVILLE


HECTOR
ULYSSES
PIKE
SUSQUEHANNOCK STATE FOREST
STATE GAME LANDS NO 64
Stiles Hill
Leech Hill
Parker Hill
Sunderlinville
West Pike
Loucks Mills
Tubbs
Hollow
Creek
Pine
Genesee
Forks
Judson
Meeker
Hardscrabble
Cushing
California
Dry Run
Phoenix Run
Johnson Brook
Lookout Tower
Telescope
Radio Towers
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Primary highway hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U.S. Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION
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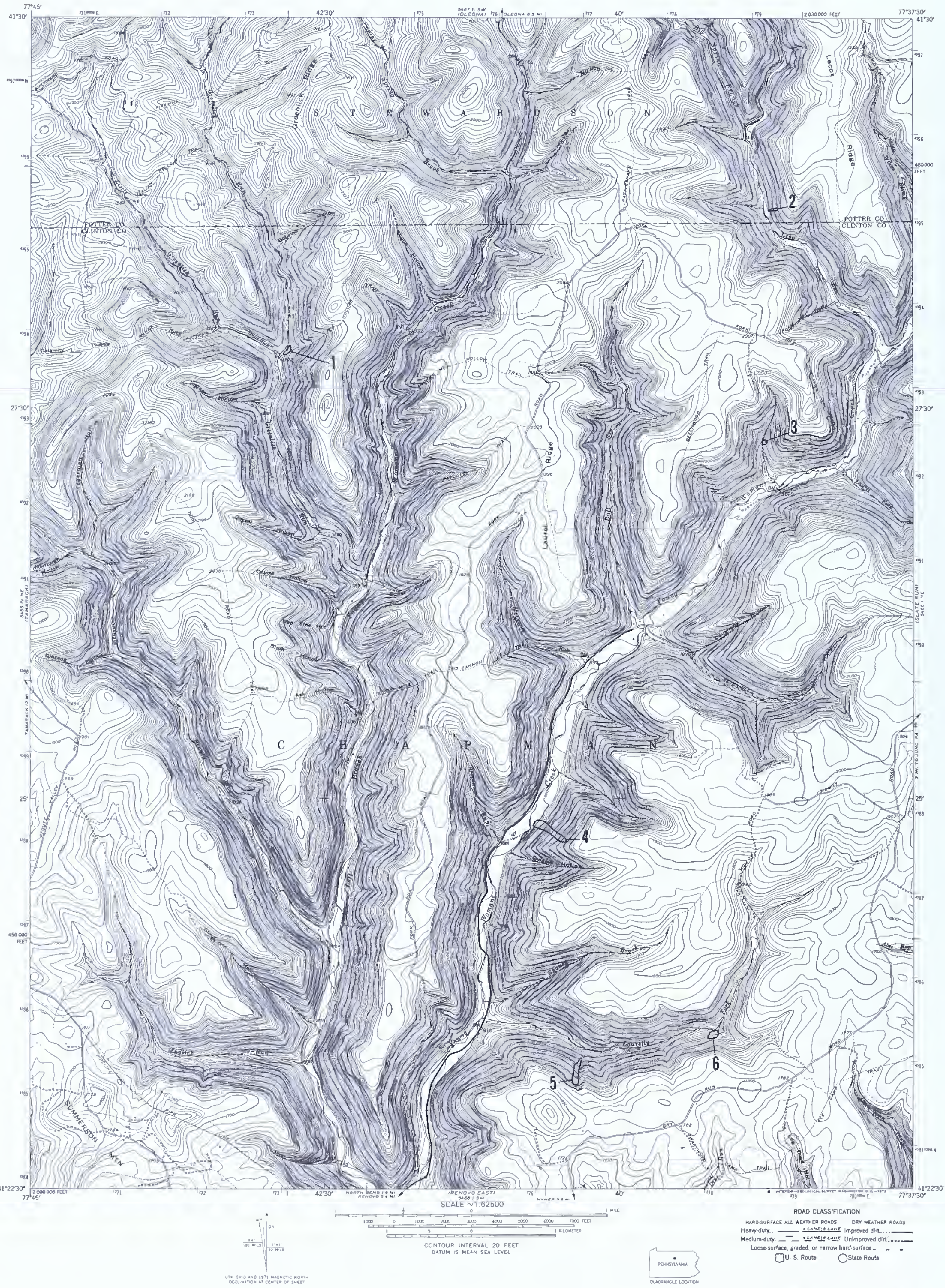
WEST PIKE


JACKSON
PINE
COGAN HOUSE
STATE GAME LANDS NO 75
STATE GAME LANDS NO 114
Fishermans Point
Club House Point
Jackson Corners
Steam Valley
Beech Grove
White Pine
Cogan House
Buckhorn Mountain
Larrys Creek
Laurel Mtn
Green Mtn
BLOCKHOUSE
Blockhouse
Flicks
Wolf
Bear
Buck
Roaring
Trout Run
Salladasburg
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U S Route
State Route
PENNSYLVANIA
QUADRANGLE LOCATION

WHITE PINE

WILLIAMSPORT



YOUNG WOMANS CREEK

EXPLANATION

HIGH-SUSCEPTIBILITY ZONE

This zone is highly susceptible to landslide occurrence. It includes areas of high landslide incidence and areas where geologic and topographic conditions are likely to lead to landslide occurrence. Prior to construction in these areas, site-specific terrain investigations should be undertaken to determine potential slope instability. Design for construction should incorporate appropriate engineering procedures to avoid damage from landslides. See text for descriptions of specific areas within this zone that represent local landslide hazards.

MODERATE-SUSCEPTIBILITY ZONE

This zone is moderately susceptible to landslide occurrence. It includes areas of some landslide occurrence and areas where geologic and topographic conditions may lead to landslide occurrence. Prior to construction in these areas, site-specific terrain investigations should be undertaken to determine potential slope instability. Design for construction may require engineering procedures to avoid damage from landslides. See text for descriptions of specific areas within this zone that represent local landslide hazards.

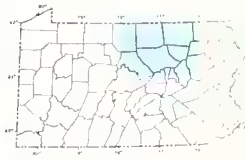
LOW-SUSCEPTIBILITY ZONE

This zone is least susceptible to landslide occurrence. It includes areas where landslide activity is unlikely except during times of heavy precipitation or after alteration of surface conditions by construction. Prior to construction in these areas, site-specific terrain investigations to determine potential slope instability are generally unnecessary.

NOTE: Information on this plate is intended as a general [illegible] not be used as a substitute for detailed geologic, engineering, [illegible] investigations. Landslide susceptibility is based on geologic [illegible] areas with known landslides. Each mapped zone may contain [illegible] where landslide susceptibility is different from the susceptibility [illegible] Otherwise stable slopes may be susceptible to landsliding [illegible] tion by man or unusual moisture conditions. Additional [illegible] be found in the report accompanying this map.

SYMBOL

• Location of inventoried landslide



LOCATION OF AREA

LANDSLIDE SUSCEPTIBILITY IN THE WILLIAMSPORT 1- BY 2-DEGREE QUADRANGLE, PENNSYLVANIA

BY

HELEN L. DELANO AND J. PETER WILSHUSEN

1993

SCALE 1:250,000

CONTOUR INTERVAL 100 FEET
WITH SUPPLEMENTARY CONTOURS AT 50 FOOT INTERVALS
DATUM IS MEAN SEA LEVEL

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